POWER

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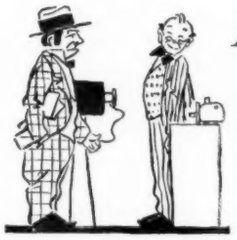
The Genius

By R. T. Strohm

HE MADE a collection of odds and of ends
Such as pieces of piping, old elbows and bends,
Bolts, nuts, pins and levers, a hundred or more,
Some valves—quite a heterogeneous store.
He pottered by morning, he tinkered by night
At putting the pieces together just right,
And after much threading and filing of scrap,
He proudly announced he had made him a trap.

HE PUT it in action, this child of his brain,
At draining condensate away from a main;
But though it apparently worked like a dream,
It passed a continuous current of steam.
However, its maker was blissfully blind
To every defect in the thing he'd designed;
He strutted about with a pigeon-like chest
And lorded it fearfully over the rest.



A LOCAL reporter, who heard of the news,
Called in with his camera, took a few views,
Propounded some questions, and after a while
Came out with a story quite lurid in style,
Declaring the trap was the greatest thing seen
Since Howe had invented the sewing machine;
And though that was stating the case rather strong,
It jollied the simple inventor along.

HE SCRAPED and he saved till he gathered the price
To pay for a patent upon the device,
And then he discovered, with keenest chagrin,
That excellent traps were as common as sin;
He saw the exorbitant price he had paid,
In labor and time, for the one he had made;
Whereat his disdainful and arrogant pride
Crawled sheepishly back to its kennel and died.

BUFFALO'S NOTABLE POWER PLANT

BY CHARLES H. BROMLEY*

There is certainly at the present time (December, 1896) no insuperable difficulty as a matter of engineering simply in designing to meet demands for pressures as high as those which in 1835 to 1845 were handled successfully with the crude facilities of those times (800 to 1000 lb.) by Perkins and Aldans; nor is there any difficulty today in proportioning an engine to work steam of any pressure that may be found financially desirable. [These pressures were really experimental.—Author.] Given a safe and durable and efficient superheater and the engineer will have the power to adjust his temperatures and pressures of working fluids to any limit that may be set by the character of materials in his boiler and engine, and to secure the best adjustment of the thermal to the dynamic limit.—Prof. Robert H. Thurston, in the "Transactions of the American Society of Mechanical Engineers," 1897.

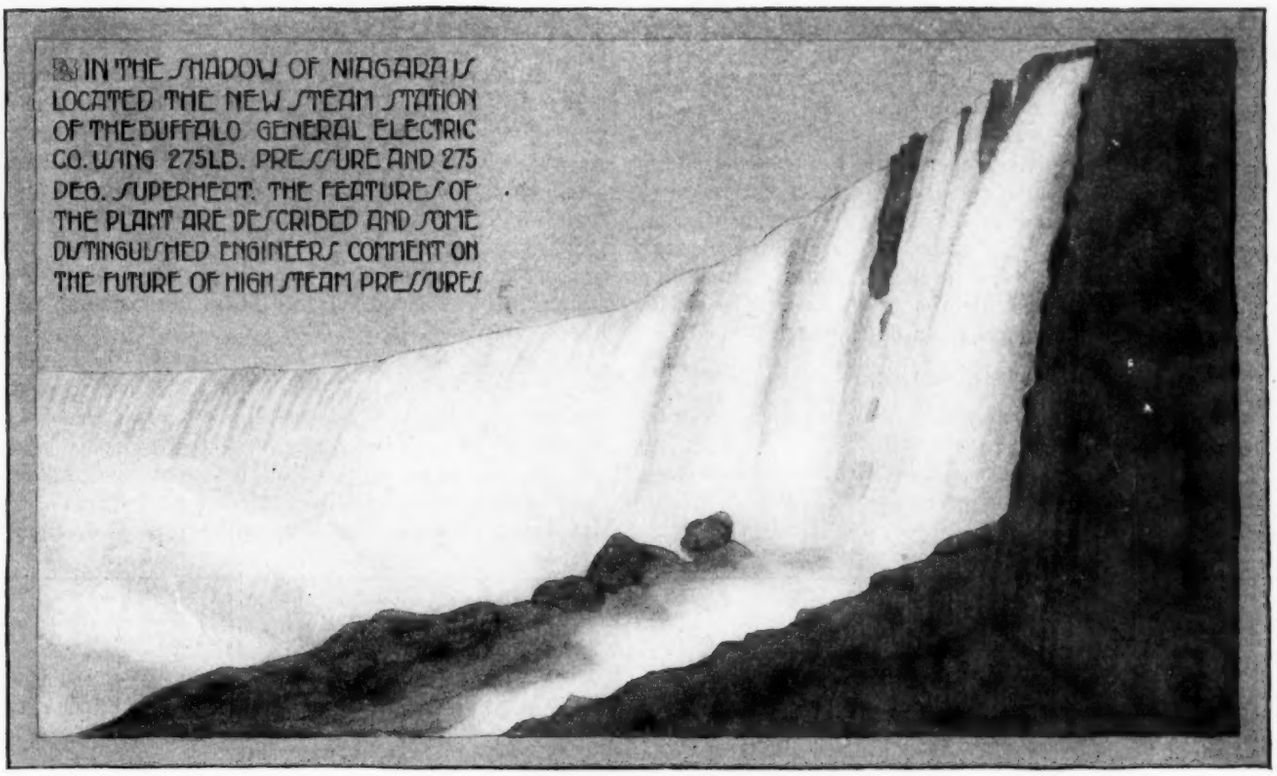
Fifteen years ago hydro-electric power developments were looked on as a choice investment, worth lots of money at almost any cost. Water powers were developed that cost $200, $250 and $300 a kilowatt. Today you could not get money for an investment of that kind because the steam turbine has risen so high in efficiency and economy and decreased so much in first cost that it has driven out all possibility of developing many of these water powers. Take the case of Niagara Falls, where there is no dam required and where there is practically an unlimited supply of power. The steam-turbine plant can compete with Niagara Falls power today, as long as the load factor for the Falls plant is less than 50 per cent. Ordinarily the only chance for financially successful water-power development is on high load factor.—Henry G. Stott, before the New York Section of the American Society of Mechanical Engineers, May, 1916.

Somewhere in the archives of the English Parliament may be found the record of an attempt by Boulton and Watt to forbid Trevithick from using pressures a little greater than atmospheric in a steam engine. This was in 1806. Pressures approaching 300 lb. have for some time been used in marine practice, particularly in torpedo boats, but pressures as high as these had not been used in stationary boilers in America until recently.

Not perhaps since the installation of those now famous turbines at Hartford, Conn., in 1902 has a plant been more vaticinal than the River Station of the Buffalo General Electric Co. Three things chiefly lend unusual interest to it—the highest pressure to date[1] in actual service in American stationary large-plant practice, 275 lb.; the highest superheat, 275 deg. F., giving a total temperature of 689.4 deg. F.; and the fact that the location is in the very shadow of Niagara, where Nature has provided abundant water power without the expense of building a dam. Fig. 1 shows a construction view, and Figs. 2 and 3 show plan and sectional views of the station. One can better appreciate the Buffalo plant and what it presages by first considering the mechanical and thermodynamic factors influenced by high pressures and high superheat. Obviously, the mechanical and economic promise of the Buffalo installation can best be had by a glance backward, which is afforded in a graphical way in Fig. 6, which shows the progress of pressures and superheat not only in stationary, but in all classes of service over a long period. It is interesting to note the use of superheat from the time of Hirn, who was the first to successfully apply it in 1855, to about 1873, when pressures considerably higher than the then customary 50 or 60 lb. were beginning to be employed. Then, owing to the lack of suitable lubricants and construction materials, the maintenance cost due to the temperatures consequent to the increased pressures caused superheat to be generally abandond until about 1898. At this later time steel for fittings and parts was substituted for cast iron, and superior lubricants, made available by the introduction of

*Associate editor of "Power."

[1]Two turbine plants have been designed for 350 lb. and 225 deg. superheat, but are not yet completed.


IN THE SHADOW OF NIAGARA IS
LOCATED THE NEW STEAM STATION
OF THE BUFFALO GENERAL ELECTRIC
CO. USING 275LB. PRESSURE AND 275
DEG. SUPERHEAT. THE FEATURES OF
THE PLANT ARE DESCRIBED AND SOME
DISTINGUISHED ENGINEERS COMMENT ON
THE FUTURE OF HIGH STEAM PRESSURES

mineral oils, gave immediate possibilities for thermodynamic gains by the use of superheat, though engineers generally have been content to set 150 deg. F. as a maximum—at least until recent years.

After all, it is quite natural that engineers should look to higher temperatures or to a greater heat drop as the most immediate field for improvements in steam-engine economy. It is quite certain that we may not hope for any new type of prime mover in the immediate future, and turbine economy ceases to appreciably improve in unit capacities above 35,000 to 40,000 kw. We know from experience that boiler efficiencies appreciably greater than those now obtainable are not likely to be attained, unless surface combustion has unexpected possibilities.

The performance of well-designed boilers and stokers is indeed a tribute to those who have brought about their advance toward perfection. Consider the Delray tests (*Power,* Dec. 5, 1911, p. 840) for example. The writer is aware that oil approaches the ideal as a boiler fuel and that some remarkable and reliable combined efficiencies have been obtained: U. S. "Melville" tests, 82 per cent.; Babcock & Wilcox Co.'s Bayonne tests, 82.5 per cent. Some other reported tests are: Pacific Light and Power Co., 83.3 per cent.; Northern Texas Traction Co., 83.6 per cent.; Dallas Electric Co., 84.2 per cent.

After one has looked about, one begins to appreciate that excepting the 10 or 12 per cent. gain that may be had by increasing the heat range by going to higher pressures or higher superheat, there is no other source, as far as can be seen at present, for bettering the economy of the steam plant.

While an increase of the high pressures of today—180 to 225 lb.—to 600 lb., which has been the pressure much discussed, inspires one's enthusiasm, it is likely that this will not come in a veritable jump as one might be led to conclude. As Dr. D. S. Jacobus aptly remarked to the writer, "It is one thing to use 500 or 600 lb. on an experimental boiler for a short time and quite another to use this pressure day after day in a commercial power plant." Then, too, to use such pressures in an existing plant would mean changing nearly the whole steam side of the station. It seems obvious that the modern large plants already built cannot do this and find it worth while. In new plants 300 to 350 lb. is likely the point at which there will be a long pause before going higher.

Suitable materials of construction will be had, but the fact remains that leakage would be considerable over the blades of a turbine as now constructed with steam of such density—0.95 cu.ft. per lb. for 600 lb. and 100 deg. F. superheat. Because with these high pressures the dew point is advanced much nearer to the comparatively inefficient high-pressure stages of the turbine, serious obstacles seem to be in the way of an immediate increase to 600 lb. or thereabouts. The high-pressure end of the turbine using such extremely high pressures would, of course, be of the impulse type to step down the pressure so that the reaction blading could, without undue length of rotor, care for the expansion of the steam down to the condenser pressure. It is likely that from now on large turbines will be ordered provided so that a high-pressure wheel may be put on if it is desired to considerably increase the boiler pressure after installation. This has already been done at Boston. The higher the pressure the greater the leakage, no matter what type of turbine is used.

It is interesting here to recall that Ferranti in his turbine using steam at 150 lb. gage and 400 deg. F. superheat, total temperature of 766 deg. F., provides each row of both rotor and stator with a shroud carrying strips of graphite which protrude above the shroud. The graphite rubs the surface of the casing and of the rotor, producing minute clearances without danger of freezing. The use of such a dense medium as steam at 600 lb. and 100 deg. F. superheat—1 lb. per 0.95 cu.ft.—may or may not make

necessary some such construction as Ferranti's, for Ferranti dealt with heat chiefly, whereas with 600 lb. and 100 deg. superheat there are both high pressures and high total temperatures to be handled.

With the use of very high pressures and superheats and consequently high total temperatures, the question of the behavior of metals under these temperatures and pressures becomes of grave importance. Below are some of the materials used for various turbine parts, and the curves,[2] Fig. 7, show the effect of high temperatures upon the physical properties of some of these metals. The elastic limits and elongations are given on the curves.

Turbine Materials

Casings: High pressure, cast steel; low pressure, cast iron.

Shafts: Ductile steel such as Siemens-Martin steel, forged or nickel steel (low percentage, 1.5 to 4.5 per cent. of nickel).

Gland cases: Usually brass with cast-iron channel rings for carrying the carbon packing. The blading used by most builders is of special alloy, and while the curves shown may not be true of these builders' compositions for specific temperatures, they are likely true as regards the general behavior of the metals in the temperature zone given by the present and the anticipated pressures and superheat.

Another thing that will be watched with much interest is the wheel friction should steam pressures continue to approach the expected 600 lb. There is considerable difference between steam at 2.68 cu.ft. per pound and that at 0.95 cu.ft. per pound, the density of 200 lb. and 100 deg. F. superheat and 600 lb. abs. and 100 deg. superheat respectively. While it is generally recognized that steam friction on wheels is indeed appreciable, the loss occasioned by this friction is most difficult of accurate determination. In fact, Stodola's experiments and formulas derived therefrom are the most widely accepted, though

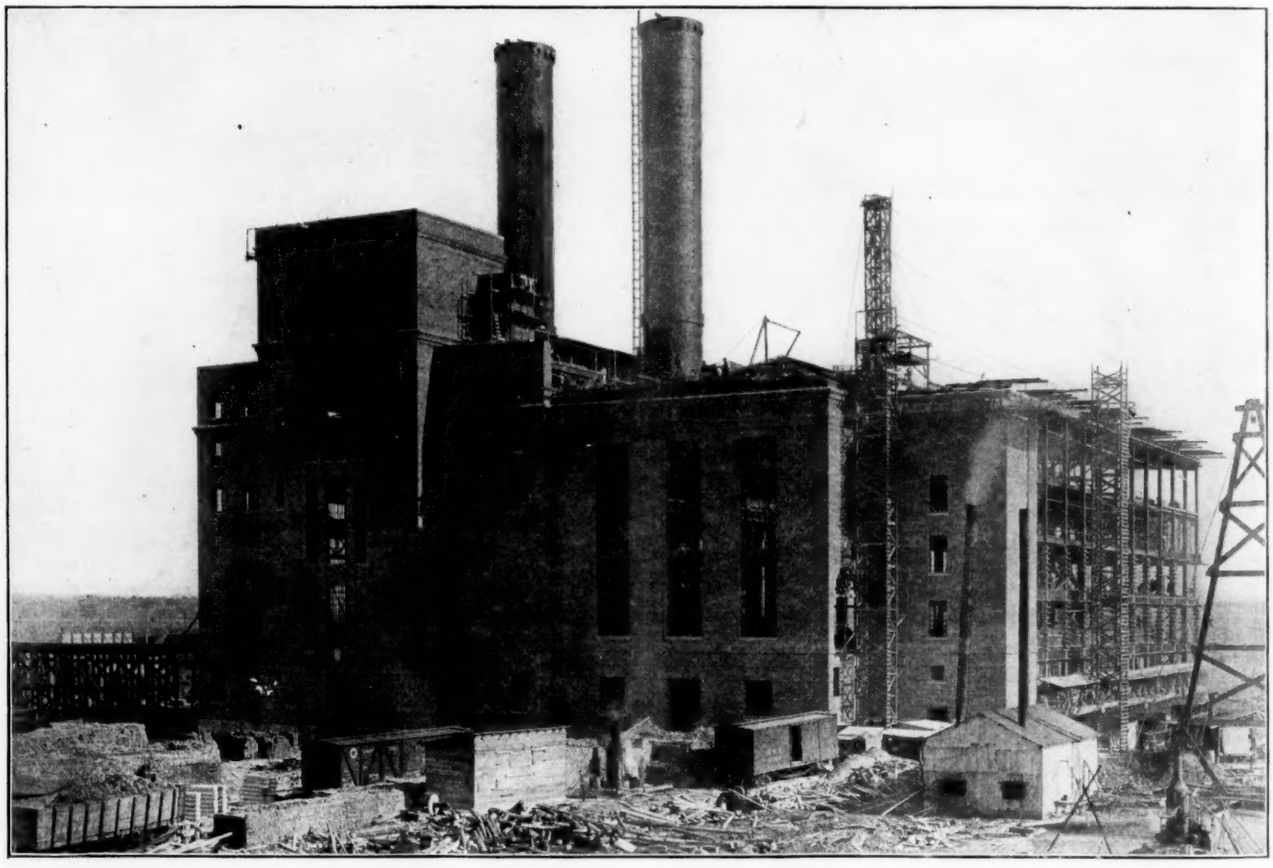


FIG. 1. CONSTRUCTION VIEW OF RIVER STATION, BLACK ROCK, BUFFALO, N. Y.

The construction of this station is perhaps a world's record as to time. Ground was broken in January, 1916, and the station was put in commercial operation in November of the same year, though delivery of material and equipment was excruciatingly slow due to disturbed industrial conditions

Wheels: High velocities, forged steel and nickel steel; low velocities, cast steel.

Diaphragms: Usually cast steel or with cast or rolled steel rim with arch of diaphragm of pressed steel plate, riveted.

Blades: Drawn brass or bronze, also nickel steel and monel metal.

Nozzle boxes: Cast steel, cast iron or brass.

known to be unreliable for general application. Konrad Anderssen, after numerous experiments on DeLaval wheels, found that the resistance to rotation in the wheel is approximately proportional to the density of the steam and that it increases with the fifth power of the diameter (wheel) and the third power of the revolutions.[3]

[2]Plotted from values given by Brogowsky and Spring, "Valve World," January, 1913, and reproduced in Mark's Handbook.

[3]Those interested in the subject of wheel friction are referred to the following: "The Steam Turbine," by Stodola, pages 18, 48, 52, 38, 129. For "Experiments by Odell" see "Engineering" (London), Jan. 1, 1904. For results of experiments by Lewicki, "Zs. d. der Deutsch. ingen.," page 492, Apr. 4, 1903; Holzwarth, "Power," page 50, January, 1907; Buckingham, "Windage Resistance of Steam Turbine Wheels," Bureau of Mines Bulletin No. 208.

Probably one of the most widely used formulas for wheel friction is that of Dr. Lasche, Director A. E. G. Turbine Works, Berlin, Germany, which is as follows:

$$P = \frac{A}{5.5} \times \left[\frac{r.p.m.}{1{,}000}\right]^3 \times \frac{dl}{V}$$

Where P denotes power absorbed in kilowatts, d the diameter of the wheel in inches, l the length of the blade in inches, V the specific volume of the steam and A a constant which is unity (1) for a wheel carrying one row of blades, 1.2 for a wheel with two rows of blades, 1.7 for a wheel with three rows and 2.5 for a wheel carrying four rows. This formula is good for wheel diameters from 35 in. up to 47 in. and for blade lengths from ¾ in. to 2 in.[4]

The opinions of some distinguished engineers on the future of higher boiler pressures appear on page 213.

Much of the power required for the industries at Niagara Falls and for some at Buffalo has heretofore been exported from the Canadian side of the Niagara River. The Canadian authorities have curtailed the sale of this power to American industries, and for this reason chiefly the River Station of the Buffalo General Electric Co. was built at Black Rock, just outside the city limits of Buffalo, New York. Already some of the industries at the Falls are building huge works contiguous to the new steam plant.[5] The station was planned for 200,000 kw. capacity, three units each of 20,000 kw. at 90 per cent. power factor (each a horizontal single-cylinder, 13-stage turbine) being installed initially; future units are to be 30,000 or 35,000 kw. The fourth machine will be of 35,000 kw. capacity. A world's record has likely been made as regards time of construction. The ground was broken for this work in January, 1916, and the station was put in commercial operation in November of the same year, a truly remarkable performance in normal times, to say nothing of conditions such as we have just passed through with regard to difficulties in obtaining materials, labor and other necessities for completing a large engineering job of this kind. The time is all the more remarkable when one realizes that the conditions of steam temperature and pressure required a considerable amount of special material.

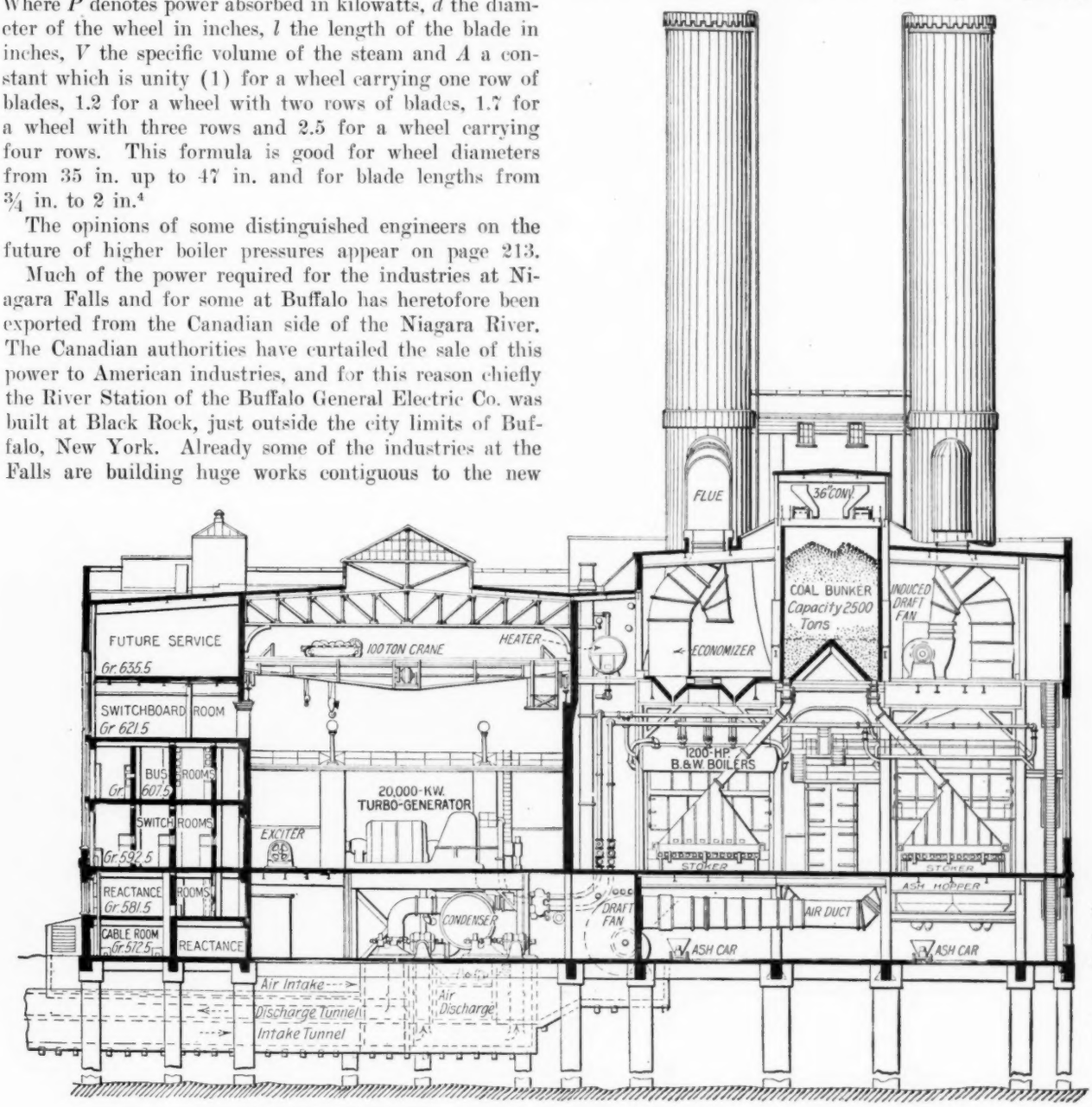


FIG. 2. SECTIONAL ELEVATION, RIVER STATION, BUFFALO GENERAL ELECTRIC CO.

The River Station is the property of the Buffalo General Electric Co., of which Charles R. Huntley is president. The late Henry G. Stott (deceased Jan. 15, 1917), superintendent of motive power, Interborough Rapid Transit Co., New York City, and associated with Mr. Huntley at Buffalo from 1891 to 1901, was consulting engineer; the Stone & Webster Construction Co., Boston, were the designers and constructors under the general

[4] See "Design and Construction of Steam Turbines," by Martin; Longmans, Green and Co., New York.

[5] Near the station the Acheson Graphite Co. and the United States Alloys Co. are building large works and have contracted for large blocks of power. The Wickwire Co. will use considerable of the station's output for steel production.

direction of Mr. Stott. P. F. Sellers, of the Buffalo General Electric Co., was general superintendent on the job, and C. F. Dixon, formerly assistant to Mr. Stott at New York, is superintendent of the station.

Only the most unusual features of the station are treated here. A table of unit capacities, ratios, ratings, etc., that gives considerable engineering information relative to the plant in condensed form and suitable for insertion in one's notebook, is appended. Mr. Stott did not cover the turbine steel foundations with concrete as he did those at the Seventy-fourth Street Station, New York City. Moreover, circulation of condensate through the main turbine bearings has been provided for by Mr. Dixon. The supply is taken from the hotwell discharge with a head of 25 ft., the temperature seldom being above 90 deg. F. The advantages are obvious.

The plant is insured against loss of excitation by providing Terry duplex exciter sets, each 300 kw. exciter being direct-connected to an induction motor at one end and to a steam turbine at the other. The governing mechanism of the turbine is so arranged that if power for the induction motor fails, the turbine will automatically pick up the load. In case of trouble on the main circuits the exciters will continue in service, while with the ordinary motor-driven exciters the exciter unit shuts down as soon as the voltage of the main circuit fails. Another advantage of the duplex exciter drive is that it gives the exciter unit a higher all-day efficiency than either a motor-driven or a steam-driven exciter. The governor on this unit can be adjusted so as to lead any desired

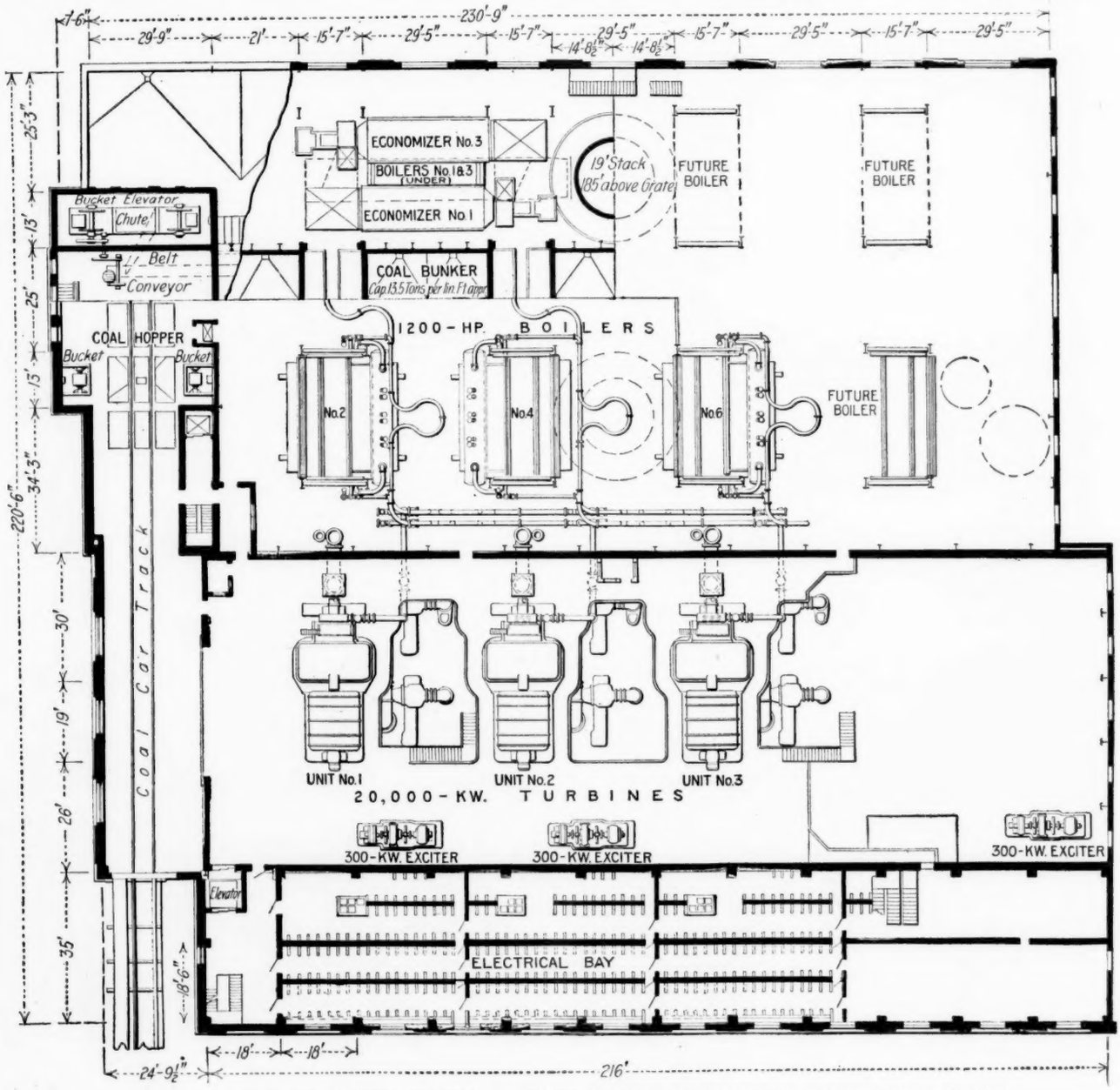


FIG. 3. PLAN VIEW, RIVER STATION. A FOURTH UNIT OF 30,000 KW. HAS BEEN ORDERED

amount of steam into the exhaust system up to the full capacity of the turbine drive and yet maintain the emergency feature; that is, adjustment is done on the governor and not on the throttle valve. The exciter turbines use the boiler pressure of 275 lb. with 275 deg. F. superheat.

Each condenser has two 25,000 gal. per min. at 650 r.p.m. Westinghouse centrifugal pumps driven by geared turbines. The 30-in. Crane valves in the circulating-water lines are hydraulically operated. Following his practice

at the Seventy-fourth Street Station, Mr. Stott placed rubber expansion joints in the circulating-water piping—one at the discharge valve, one each for the suction and the discharge at the pump, and one at the condenser. Heavy piping at the condensers is supported by springs.

The longer you remain at the station the more you feel like the boy in the candy shop—you do not know just what interests you most. Surely the high-pressure steam

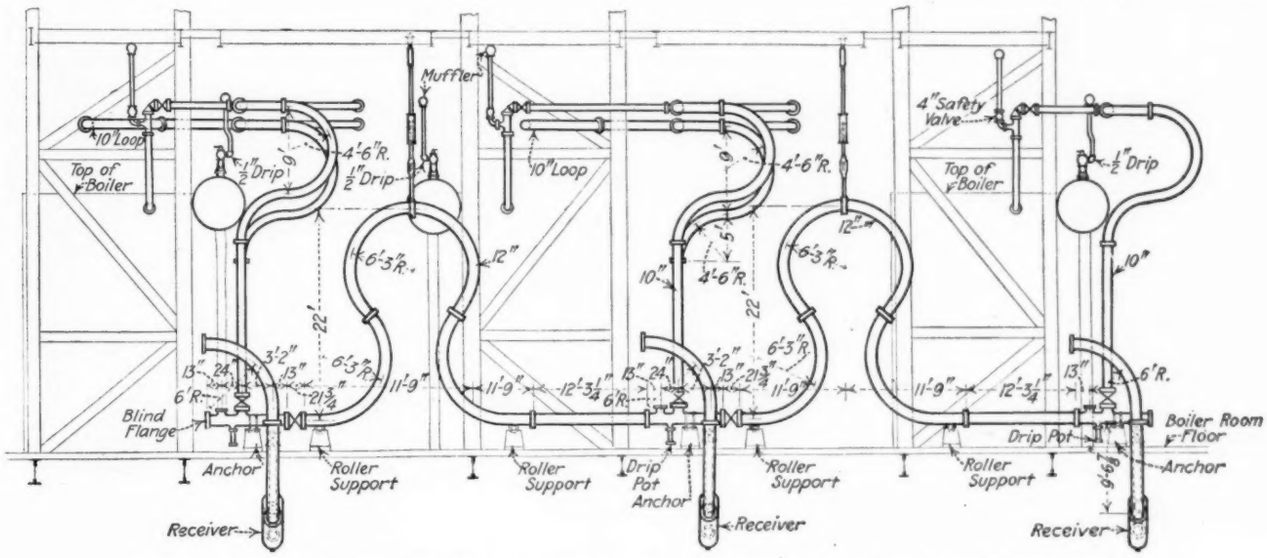


FIG. 4. ELEVATION OF STEAM MAIN (TWO ARE USED) AND LEADS FROM THREE BOILERS

The exceedingly large bends which rise about 23 ft. above the door must care for expansion due to 700 deg. F.—nearly 5 in. for distance between two anchors. Woven asbestos gaskets are used. The bends from the receivers go to the turbines

piping is the most impressive. As you stand facing the boiler-room wall, the bends in the 12-in. steam mains rise 23 ft. above the floor—as high as the boilers. Each bend, as shown in Fig. 4, consists of three parts—two 45-deg. bends from the horizontal joined by a U-bend of 6 ft. 3 in. radius, producing a double offset bend with four joints. There are two 12-in. headers or mains, the 10-in. leads from the boilers on one side of the house going to one of these, the leads from the boilers on the other side going to the other header. One connection from each header joins a receiver at each turbine, with which 15-in. diameter bends connect the turbine. Fig. 4 shows how well provided is the piping for the movement that 275 lb. pressure and 275 deg. F. superheat make inevitable. Each bend should care for an expansion of about 11 in., allowing that it should have less than a double-offset bend on account of the joints within the bend and more than a combination U- and quarter bend. There is, roughly, 82 ft. of piping, including the bend, between anchors. Using 0.0000065 as a coefficient, each bend must care for an expansion of

$$82 \times 0.0000065 \times 629 = 0.3352 \text{ ft.} = 4\tfrac{1}{32} \text{ in.}$$

(The 629 is the total temperature due to 275 lb. pressure (gage) and 275 deg. superheat, minus 60 deg.) The gaskets are of woven asbestos, and their behavior up to this writing has been excellent. However, observation of these under service will continue to afford keen interest.

For such high pressure and temperature as is used at this plant, unusual care must be given to the selection of the valves and fittings. All valves on main steam piping, except throttle valves, are gate valves. The valves in the high-pressure steam lines are of steel. Although the steam velocities at this plant are not unusually high, the valves have been provided with seats, Fig. 11, designed to minimize the cutting and scoring effect of wiredrawing. It is evident from the illustration that the disk must be raised a considerable distance from the seat, which is the horizontal surface, before an appreciable opening is made between the protecting rings or tongue, which, as may be seen, fits into the groove in the disk. These valves are from the Edward Valve Manufacturing Co.

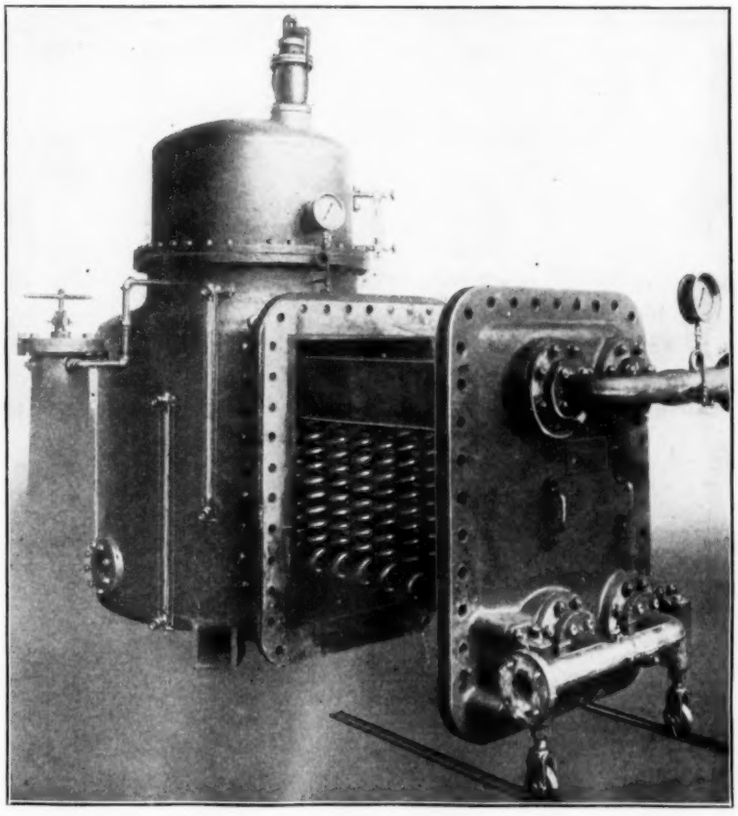


FIG. 5. MAKE-UP FEED-WATER EVAPORATOR

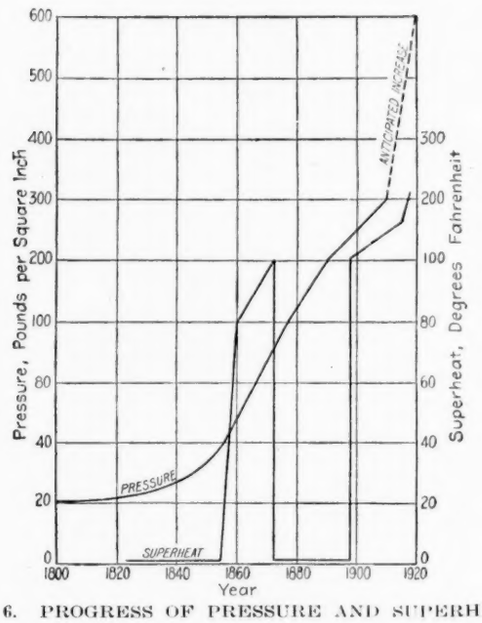


FIG. 6. PROGRESS OF PRESSURE AND SUPERHEAT

A sectional view of one of the boiler drumhead stop and check valves is shown in Fig. 10. This is the type of stop and check valves used in the feed lines. These valves, like the main stop valves, are of cast steel, extra heavy, with monel seats, disks and stems; the other trimmings are of phosphor bronze. The physical properties of the steel bodies are: Tensile strength, 70,510 lb. per sq.in.; elastic limit, 34,590 lb. per sq.in.; elongation, 31 per cent. As shown, the upper part of the disk is cylindrical, moving up and down in a cylinder into which the water is let through small passages to provide a cushioning effect, which prevents chattering or hammering of the disk upon the seat. These valves are made right and left to permit of symmetrical piping on multi-drum boilers. The smaller stop valves are of forged steel, having the disk or seat screwed in instead of being formed or pressed in. The seat, disk and stem are of monel metal. This type of valve is shown in Fig. 9, and is used for the superheater drains, etc. Because of the setting, large size and great capacity, the stokers are of unusual interest. They are of the Riley inclined underfeed type, two 15-retort stokers being installed back to back under each 11,400-sq.ft. Babcock & Wilcox cross-drum water-tube boiler. All ashes are discharged through the opening between the stokers. This arrangement has the advantage that there is no bridge-wall to which clinker may adhere. It is the largest duplex stoker setting ever built. The furnace width at the grate level is 23 ft. 10⅞ in. The depth of furnace is 17 ft. 5¾ in., which is double that of an ordinary setting. The total grate area is 417.8 sq.ft., and the ratio of grate area to boiler-heating surface is 1:27.3. This is probably the most liberal grate surface per unit area of heating surface used in power-plant practice. The stokers are set so that there is a distance of about 10 ft. 10 in. from the top of the grate to the front header and 6 ft. 0 in. from the top of the grate to the rear header, forming an extra-large combustion chamber, which is essential when forcing to high capacities. The advantage of a combustion system of this size and type is readily apparent when it is remembered that the capacity is increased as the cube of the size and that the radiation is only increased as the square of the size.

When the boilers are operating at normal rating, the rate of coal fed by the plungers is 127 lb. per retort per hour. The stoker is capable of being operated to feed 1,000 lb. of coal per retort per hour. When feeding 700 lb. per retort per hour, or 10½ tons per boiler per hour, which is well within easy operation for the stokers, the boiler will evaporate about 160,300 lb. water per hour from and at 212 deg. F., or 14.4 lb. per hour per sq.ft. heating surface. Consequently, overload capacities can be obtained that would have been deemed impossible a few years ago.

Estimating the average thickness of fuel bed as 2 ft., there would be in the furnace at all times 23 tons of green coal and coal in the process of combustion. As will be seen, this quantity is more than twice that fed per hour by the stokers when the boiler is operating as mentioned. The fuel bed therefore is always ready for fluctuation in load and capable of taking care of sudden demands for steam. From the foregoing it is seen that these boilers are much over-stokered as compared with usual practice. Because of this and owing to the load dropping about 40,000 kw. from 12 noon to 12:20, "holding down" the boilers during and immediately after this avalanche of load presents a nice little, though not serious, "wrinkle"

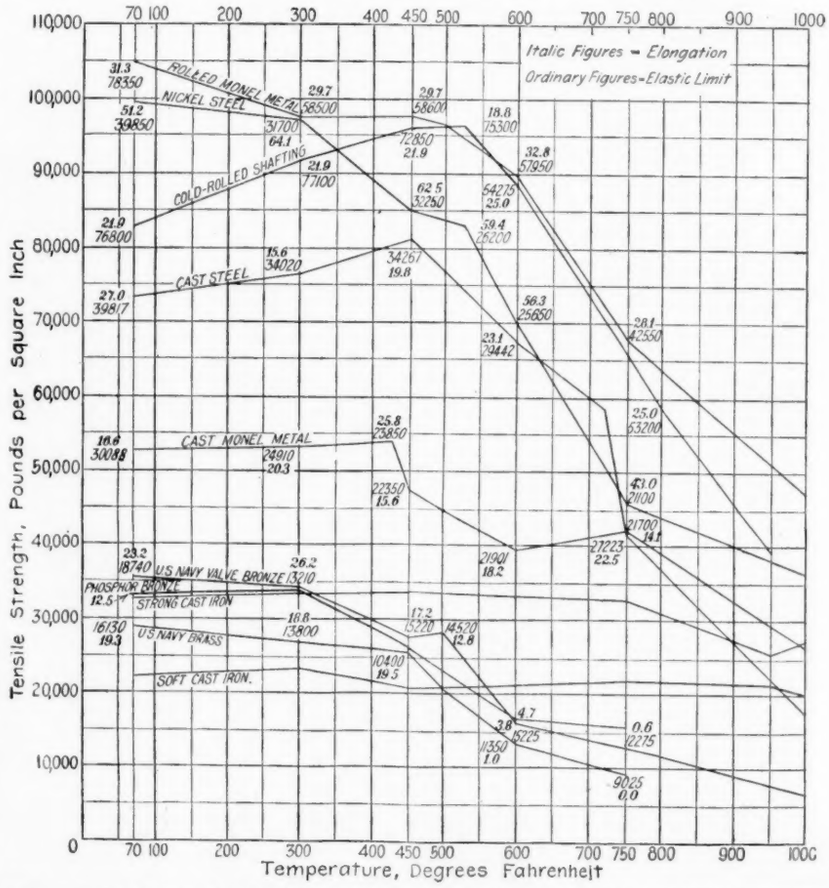


FIG. 7. BEHAVIOR OF TURBINE MATERIALS UNDER HIGH TEMPERATURES

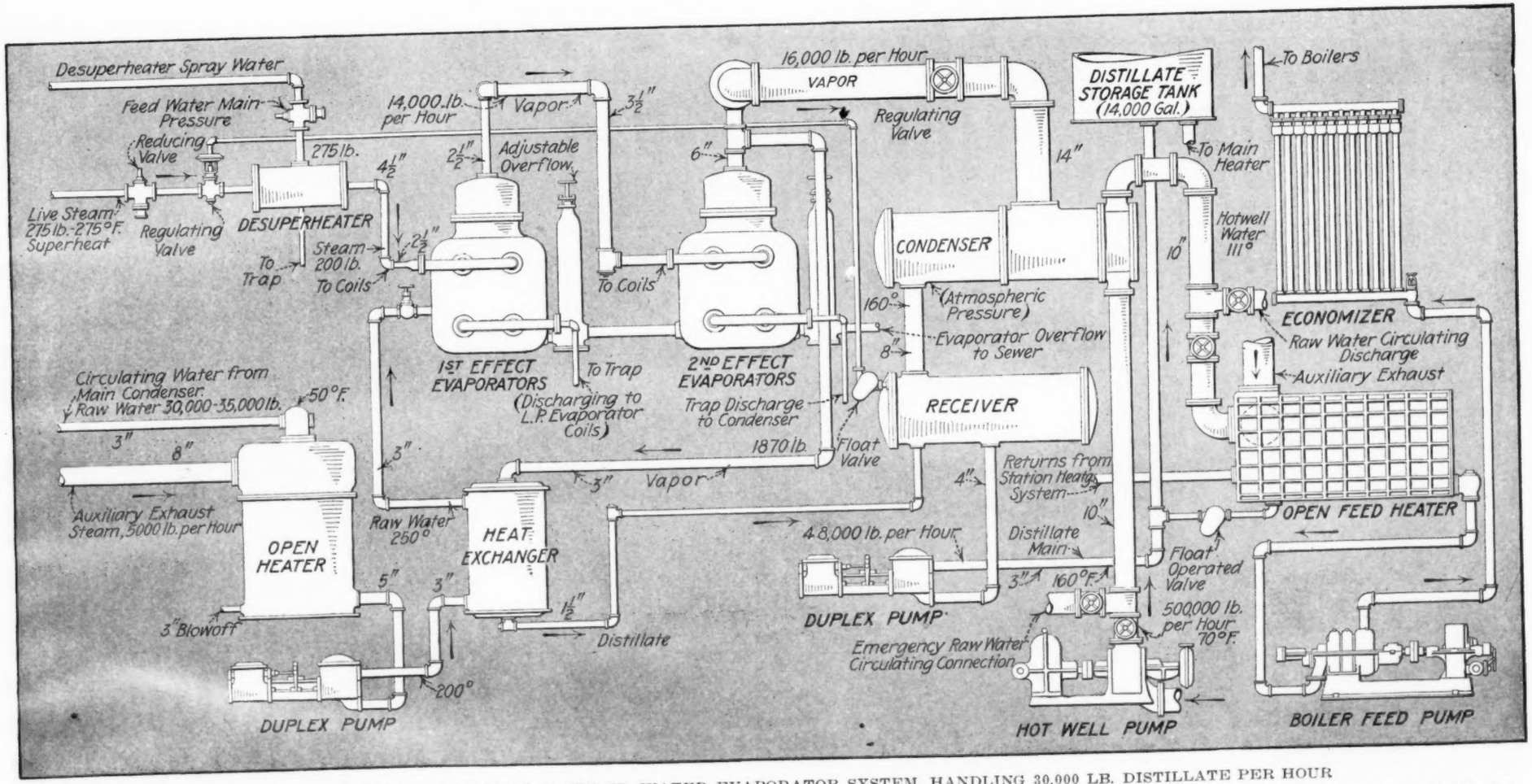


FIG. 8. DIAGRAMMATIC LAYOUT OF MAKE-UP WATER-EVAPORATOR SYSTEM, HANDLING 30,000 LB. DISTILLATE PER HOUR

Raw water is now taken from the Niagara River but soon will be drawn from the circulating water outlet of the main unit condensers. Begin tracing the raw water at the open heater at the left. In the condenser shown vapor from the raw water is condensed by the hotwell water which passes direct to the main open heaters. The only heat lost is that in radiation, which is small and in the blown-down water. The distillate has but 0.35 gr. per gal. of solids

for the operators to iron out. The arrangement of the stoker-dump operating mechanism for adjusting the position of the ash (dump) plates is also unique. It is compact in a gear box and bolted to the boiler-room floor. An indicator located above and in front of the handwheel used to operate the dump enables the operator to tell the position of the dump plates without opening the side observation door. The three-stage turbine-driven feed pumps have all-bronze casings—a specification first introduced, as far as the writer can determine, by the engineers of the New York Edison Co., and which is becoming more and more general. Both these pumps are of the single-suction type. Venturi meters measure the feed. The new Green type H economizer suitable for pressures up to 400 lb. is installed. Cast iron is the material used, and assuming 20,000 lb. tensile strength for the tubes (it is actually greater) and 300 lb. boiler pressure, the theoretical factor of safety is 13. The tubes and parts are heavy for such high pressure. The depth of the bearing surface for the tube in the socket in the header is unusually large, being 2¾ in., as against 2½, 2 and 1½ in. frequently used. Destruction tests (hydrostatic) on these tubes have not

produced rupture below 4,000 lb. per sq.in., and in every case they split only.

Excepting the steam piping, the writer was more impressed by the raw-water evaporator system for supplying distilled make-up feed water than by any other system or piece of apparatus in the station. With each of the 11,400 sq.ft. heating surface boilers evaporating 160,300 lb. water per hour, there must be no scale in the boilers or elsewhere in the system, where impaired heat transmission and cleaning will tend to inefficiency, unreliability and delay. The evaporator system is located above the boiler room. The makeup water evaporator system has a capacity of 30,000 lb. of distilled water per hour, 24 hr. per day, the distillate to have less than 5 grains of solid per U. S. gallon, upon evaporation to dryness. In service there is about 0.35 grains per gallon in the distillate coming from the system, which evaporates at the rate of 30 lb. of distilled water per pound of steam consumed for this purpose. The steam pressure used in the evaporators is 200 lb., saturated. The raw water for evaporation is from the Niagara River and is pumped direct to the evaporator system, though later condenser circulating water will be used. The water has the following composition:

Solid	Parts per Million	Gr. per Gallon
SiO_2	8.4	0.49
Fe_2O_3 Al_2O_3	3.0	0.17
$CaSO_4$	23.0	1.34
$CaCO_3$	70.4	4.10
$MgCO_3$	29.0	1.69
NaCl	12.6	0.73

The solid content will of course be variable, as the river at this point is very wide, and owing to the high winds which blow, the water is so disturbed that the solid content is considerably greater than it is at times of low wind velocity or when the wind is blowing toward instead of from the river. The plant had been in service about three weeks at the time of the writer's visit, and the analysis of the distilled water had been shown to be as follows:

Solids	Parts per Million	Gr. per Gal
Total solids	6.0	0.35
Loss on ignition	2.29	0.13
Mineral matter	3.71	0.21

The analysis was as follows:

Solids	Parts per Million	Gr. per Gal.
SiO_2	0.45	0.026
Fe_2O_3 Al_2O	0.33	0.019
$Ca\ SO_4$	0.07	0.004
$Ca\ CO_3$	2.86	0.167
$MgCO_3$	Trace	....
NaCl	Trace	....

The water analyzed consisted not only of the water produced by the evaporators, but also of the steam from the boilers which was furnished to the evaporators. It is likely that the solid matter, or at least by far the most of it, was that in the form of dirt from the pipe lines, which had, of course, not been long in service. A diagrammatic layout of the evaporator plant is shown in Fig. 8. The plant consists of three two-effect evaporator sets, each evaporator being of the type shown in Fig. 5. The coils (heating surface) are of 1 in. outside diameter seamless drawn-brass tubing, wound in small coils so that they are quickly detachable. The entire heating surface is connected to the door of the evaporator so that it may be drawn out as shown, for cleaning or inspection purposes. It is in the evaporators where most of the scale is formed and from which the sludge is blown to the waste pipe. As will be remembered, the steam pressure is 275 lb. from the boilers and is superheated 275 deg. The heat transmission from superheated gas such as this steam, is of course not as great as when saturated steam is used, and because of this a reducing valve and a desuperheater are used to reduce the steam to saturation at 200 lb. before it goes to the evaporators. In the diagrammatic layout there are shown what appear to be two evaporators. In the actual installation there are three evaporators in the first-effect battery and a like number in the second-effect battery, all being in parallel. The second-effect evaporators discharge vapor at 25 lb. pressure which is passed to a high-heat-level condenser. As will be seen from Fig. 8, one should, to facilitate his understanding of the system, begin by tracing the lines from the raw-water line or start at the hotwell and trace the course of the condensate from the hotwell of the turbine condensers through the evaporator-system condenser

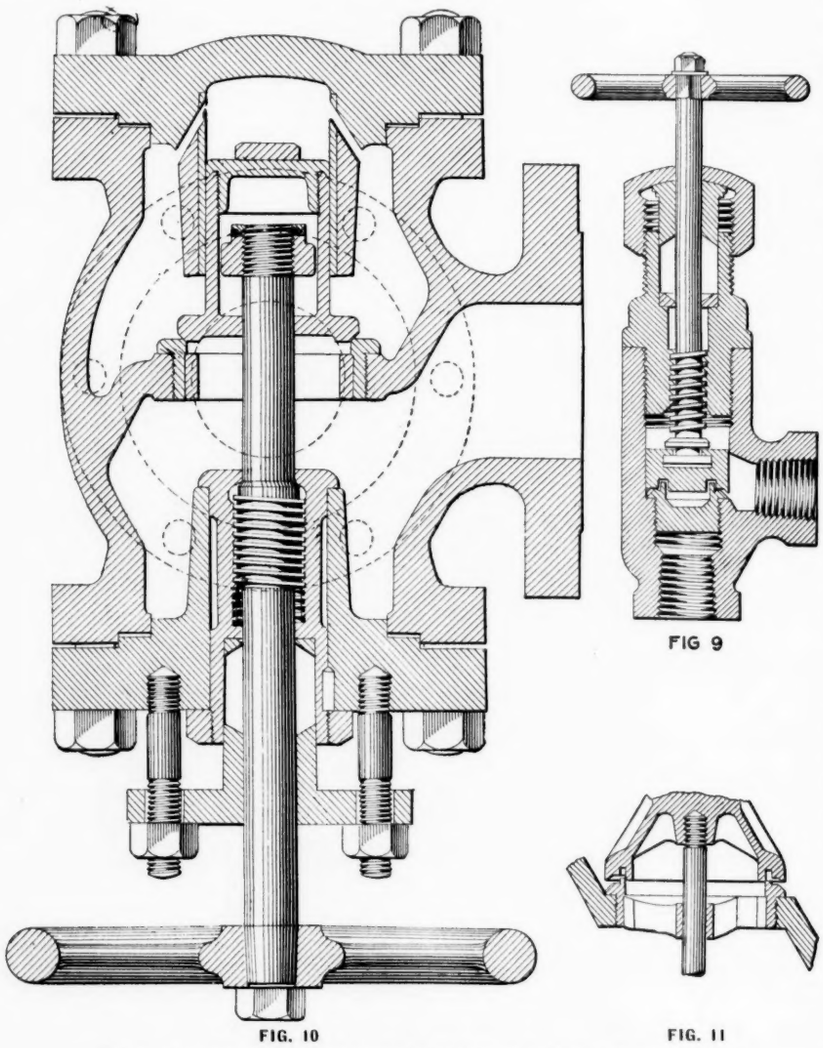


FIG. 10

FIG 9

FIG. 11

FIGS. 9 TO 11. SOME TYPES OF VALVES USED AT BUFFALO

Fig. 9—Small valve for drains, as from Superheaters, etc. Fig. 10—Type of valve on feed lines connecting drums of each boiler. Fig. 11—Seat of stop valves. The valve seats on the outer edge, and because of the tongue-and-groove construction the seat is not cut by wire-drawing of the steam

and to the main open feed-water heaters, from which it goes to the economizer and then to the boiler. The raw water which is taken from the circulating-water discharge from the main condensers enters an open heater supplied with steam from the exhaust of the auxiliaries and then passes through a heat exchanger, the shell of which is supplied with vapor from the second-effect evaporator, while the raw water which has passed through the open heater and through the coils in the heat exchanger passes on to the first-effect evaporator. The coils in the second-effect evaporator are heated by the vapor from the water surrounding the coils to the first-effect evaporator, the condensate from these coils and other sources going eventually to the main open feed-water heaters, from which the water goes to the economizers and then to the boilers. The height of water in the evaporators may be varied by the use of weir overflows, shown at the right of each evaporator in Fig. 8. The normal water level in the evaporators is from 18 to 21 in.

The aim throughout has been to make the operation of the evaporator system automatic, so that the evaporators may follow very closely, without personal attention, the output as required by the load on the plant or, to be more specific, to the feed-water requirements. All the distilled water produced drains to a receiver tank to which is connected a duplex pump governed by a float control so that with low water level in the receiver the pump will gradually shut down and beyond this level will stop. Another float control is attached to the receiver, which operates a pilot valve when there is a high water level in the receiver, and this pilot valve in turn controls the setting of the main steam valve at the desuperheater, so that as the water level in the receiver increases, there is a corresponding decrease in the amount of boiler steam admitted to

Important Data of River Station Equipment

These data show what ratios, proportions, velocities, capacities, etc., have been used in the design of this station. The capacities are calculated from the specification or guarantee figures. Unless otherwise stated, all data are based upon the apparatus now installed and on order; that is, upon 95,000 kw. turbine capacity with five boilers. Eventually three more boilers will be installed.

BOILER ROOM

Type of boilers	Babcock and Wilcox, cross-drum water tube
Number now installed	5
Anticipated station load, immediate, kw	40,000
Heating surface, each, sq.ft.	11,400
Superheater surface, each boiler, sq.ft.	3,815
Grate surface per boiler, total, sq.ft.	418
Heating surface per sq.ft. grate surface, sq.ft.	27.27
Heating surface per sq.ft. superheater surface, sq.ft.	3
Superheater surface per sq.ft. grate surface, sq.ft.	9.1
Heating surface per kw. (95,000 kw., five 11,400 sq.ft. boilers)	0.6
Working pressure, lb. per sq.in.	275
Superheat, deg. F.	275
Total temperature steam, deg. F.	689.4
Mud drum material	Forged steel
Stokers, Riley underfeed, 2 per boiler; retorts per boiler	30
Maximum capacity each retort, lb. coal per hr.	1,000
Capacity each retort at approx. 400 per cent. rating, lb. per hr.	700
Boiler rating on peaks, per cent., 350; between peaks, per cent.	100 to 250
Rating on peaks, anticipated maximum, lb. water per hr. from and at 212 deg. F.	160,300
Water evaporated per sq.ft. heating surface at approx. 400 per cent. rating, lb. per hr.	14.4
Capacity each stoker on peaks, kw.	5000 to 10,000
Coal burned per sq.ft. grate at 250 per cent. rating, lb. per hr., 26; at approx. 400 per cent. rating, lb. per hr.	50.25
Economizers, green, type H, maximum pressure, lb. per sq.in.	400
Economizer material	Cast iron
Economizer heating surface per boiler, sq.ft.	9,435
Economizer heating surface per sq.ft. boiler-heating surface, sq.ft.	1.208
Economizer surface per boiler horsepower (34.5 lb. water per hr.) rated capacity, sq.ft.	0.228

Economizer—Guarantees for each unit economizer:

Feed Water Lb. per Hr.	Temperature Leaving Economizer When Entering at 180 Deg. F.	Gas Temperature Entering, Deg. F.	Gas Temperature Leaving, Deg. F.	Gas Temperature Difference, Deg. F.
53,000	263	535	294	241
86,000	281	633	366	267
103,000	289	670	396	274
120,000	288	705	443	262

Coal	Bituminous run of mine
Coal bunker, type	Non-suspended, steel frame, concrete lined
Coal Conveyors: Two bucket conveyors, capacity each per hr., tons	200
Two belt conveyors over bunker, each 36 in. wide, capacity each per hr., tons	200
Feed pumps, 3 Jeansville, centrifugal, turbine-driven, all-bronze casings.	
Feed pump capacity per sq.ft. heating surface, gal. per min.	0.053
Makeup water evaporator system capacity, lb. per hr.	30,000
Present makeup water evaporator capacity, per cent. of hotwell supply (based on 60,000 kw. turbine capacity)	5
Main open feed-water heaters: Cochran horizontal cylindrical; capacity each, boiler hp.	10,000
Heater capacity per sq.ft. boiler-heating surface, boiler horsepower (34.5 lb. water per hr.)	0.53
Heater capacity per rated horsepower capacity of boilers, boiler horsepower	5.3
Heater capacity per lb. main-unit steam consumption (95,000 kw. @ 10.25 lb. per kw.-hr.) boiler hp	0.0308
Chimneys: Two steel-lined.	
Contractors, Lackawanna Steel Co. Builders, Merchants Iron Works, Chicago	
Height above lower grate, ft. 192; height above upper grate, ft.	185
Diameter at flue entrance, ft.	19
Diameter at top, ft.	19
Boilers per chimney	4
Coal burned per sq.ft. chimney cross-sectional area at approx. 400 per cent. rating, lb. per hr.	185.1
Forced-draft fans, Green, radial flow; number of	3
Capacity of each at 6 in. static pressure, 550 r.p.m., cu.ft. per min. (hp. 308)	210,000
Capacity of each at 4½ in. static pressure, 430 r.p.m., cu.ft. per min. (hp. 153)	150,000
Capacity of each at 3 in. static pressure, 336 r.p.m., cu.ft. per min. (hp. 67)	100,000
Induced-draft fans: Buffalo Forge Co., number of	6
Induced-draft fan capacity, each, with gas at 496 deg. F., 482 r.p.m., cu.ft. per min. (hp. 130)	120,500
Forced-draft fan capacity per sq.ft. grate, cu.ft. per min.	251
Induced-draft fan capacity per sq.ft. grate, cu.ft. per min.	288
Bunker coal storage over present 8 boilers, maximum tons	3,000
Yard coal storage at plant, tons	50,000

TURBINES

Three 20,000 kw. at 90 per cent. power factor, installed; one 35,000-kw. on order	
General Electric Co., single-cylinder, horizontal, speed, r.p.m.	1,500
Operating pressure, lb. abs.	290
Operating superheat, deg. F.	275

Performance guarantees: Operating conditions—265 lb. abs. 250 deg. F. superheat. 1-in. absolute pressure, 30-in. barometer, in condenser:

Net Kw. Load of Generator	Lb. of Steam per Kw.-Hr.
7,500	11.85
10,000	11.05
15,000	10.25
20,000	10.60

Note. For higher pressures and temperatures the following factors are used: 1 per cent. for each 15 lb. pressure for range of 25 lb. above or below normal; 1 per cent. for each 11 deg. F. superheat for range of 25 deg. F. above or below normal.

Blading material: First 2 and last 3 rows, nickel steel; intermediate rows, monel metal and nickel bronze.	
Peripheral speed last rows of low pressure blading, ft. per sec.	717
Total weight each 20,000-kw. machine, lb.	540,000
Weight of turbine per rated kw. capacity, lb.	27
Heaviest piece to be lifted by crane, tons	70
Floor space occupied by each turbine, outside measurements, sq.ft.	830
Turbine rated capacity per sq.ft. floor covered by turbine, kw.	24
Steam consumption of auxiliaries.	
At most economical load, lb. per hr., 6,100; with 70-deg. F. circ. water, lb. per hr.	10,500
At full load, lb. per hr., 9,100; with 70 deg. F. circ. water, lb. per hr.	13,500
Exciters: Three, Capacity each, kw.	300
Type	Combination turbine and induction motor drive
Builders	Terry Turbine Co.
Main unit capacity per kw. capacity of exciters, installed, kw.	105.5

CONDENSERS

Builder	Westinghouse Electric and Mfg. Co.
Total tube surface per condenser, sq.ft.	33,000
Tube area per kw. turbine capacity served by condenser, sq.ft.	1.65
Tubes, 1 in. O. D., composition,	Muntz metal (60 per cent. copper, 40 per cent. zinc)
Chief guarantee: With 70 deg. circulating water, pressure in condenser, lb. abs.	1.33
Circulating pumps, capacity each, gal. per min.	25,000
Builder, Westinghouse Electric and Mfg. Co., type, double suction, centrifugal	
Diameter discharge pipe, in.	42
Circulating-water pumping capacity per lb. steam condensed at consumption of 10.6 lb. per kw.-hr., lb.	118
Circulating pumps (two per condenser) capacity each, gal. per min.	25,000
Cross-sectional area each intake and each discharge tunnel for each unit, sq.ft.	30
Intake tunnel area per 1,000 gal. per min. circulating-water pumping capacity, sq.ft.	0.6
Screens at circulating water intake	Wire mesh, stationary
Dry-vacuum pump, type	La Blanc
Hotwell pump: Centrifugal; builder, Worthington; size, in.	4

the high-pressure evaporator. This automatically controls the output of the system. The evaporator distilled-water pump is piped so that it may discharge directly to the main open feed-water heaters or, if these heaters have their maximum water level, the distillate will pass to a storage tank above.

A complete description of the coal-handling and storage system must wait for treatment in a future article. Suffice for now that there is 2500 tons bunker storage above the boilers for the eight boilers and 50,000 tons yard storage. Transportation facilities by rail and barge right to the plant are provided. Bucket conveyors of 200 tons per hour capacity in duplicate elevate coal to the bunker, distribution at the bunker being done by two 36-in. belt conveyors. Belt conveyors also transfer coal from the river-front tower to the bunker or yard storage. It is quite an unusual layout. Each coal chute from bunker to boiler is 16 in. diameter, connecting to a spreader of unusual design, an idea of which may be had from Fig. 2.

Absorption Machine Ammonia Leaks

By H. G. Gibson

In the absorption type of refrigerating machine there are many sources of ammonia leakage. To detect these leaks in their infancy or, better still, to prevent them from starting at all should be the constant aim of those whose duties require them to operate this type of machine. It is true that one small leak alone will not result in great loss unless it is allowed to continue indefinitely, but it does not take long for several small leaks to lose enough to seriously affect the operation of the plant. The man who gets the best results out of the machine with the least expense for ammonia, other things being equal, is the one who diligently and regularly goes over his plant looking for the small leaks that may have already started as well as the loose joints that might develop into leaky joints later on.

Generally speaking, the oftener a machine is started and stopped the more likely it will be to develop leaky joints. A joint that is tight when the machine is hot and in operation may leak when the machine is shut down and comparatively cold. For this reason intermittent operation of absorption plants should be avoided as much as possible.

While there are many points at which it is possible for a leak to develop, there are some which seldom or never show loss of ammonia. The joints on those parts of the machine subject to the greatest variation in temperature and pressure are the ones most likely to require frequent attention. Among these are the stuffing-boxes around the coils protruding from the end of the generator and also those on top of the exchanger. It is a good plan to go over the bolts on such apparatus shortly after the machine is stopped and again at frequent intervals while the generator is cooling. Care should be taken not to squeeze any harder on the packing than is necessary to keep the joint from leaking. Unnecessary tension on the packing simply shortens its life and hastens the time when the joint must be repacked.

A few years ago it was the practice to pack the stuffing-boxes mentioned with lead-inserted round rubber packing. This came in long sections which required cutting when being applied. Present-day practice is to use solid rubber packing which comes in ring form. It is molded to the proper size and must be cut before it can be put in place. The cuts should be made diagonally as usual and staggered to obviate as far as possible any leakage through them.

When getting ready to pack the generator and exchanger coil boxes, the liquor in these shells should be transferred to another part of the machine and the pressure reduced as far as possible. With the generator under pressure, opening the weak-liquor valves will allow the bulk of the liquid in the generator to flow into the absorber and cooler. The next step is to get some cooling water through the generator steam coils. In some machines provision for this is made by drilling and tapping the upper steam header for a ¾-in. or larger plug, which is removed when it is desired to run water through the coils and a hose or pipe connection made to the plug hole. Running cool water through the coils will tend to condense what ammonia vapor there is in the shells and thus reduce the pressure. It is not a good plan to try to remove all the old packing, but the first three or four rings around each coil; this is because it is not possible to remove all the liquor from the generator by means of the weak-liquor line and there will always be a little in the bottom, the vapor from which would be extremely disagreeable, even if not dangerous, to one taking the old packing from the bottom of the box.

Next to the joints already mentioned, the most common sources of leakage are the stuffing-boxes on the generator and condenser gage-glass valves in the weak liquor line, and the expansion valve. It is well to pack these boxes at the same time the packing in the generator and exchanger coils is being renewed, even if they apparently do not leak; doing it then may save time and trouble later on. The gage-glass boxes on the absorber and cooler require little attention in that respect because those shells are worked under low pressure.

Trouble with Leaky Piston Rods

The piston-rod stuffing-box of the ammonia pump may or may not be a source of considerable leakage, depending on the condition of the rod and packing. A badly worn rod does not, of course, develop overnight, but the fact that it comes into this condition gradually is likely to deceive one as to its real condition unless it is examined at regular intervals. A badly worn rod should not be tolerated, for it will result in more wasted ammonia than all the other joints of the machine combined. Not only that, but it is impossible to keep the stuffing-box packing in good condition if the rod is worn or scored, and this means a clear waste of packing as well as of ammonia.

The header joints on the ends of the generator are good places to watch for leaks. The only thing that can be done if a leak develops there is to take up on the header bolts. When that fails, a new gasket is the only remedy. If the gasket on one end is renewed, renew the other.

The senses of sight and smell are usually all that the experienced operator requires in detecting leaks from joints exposed to the air, although litmus paper, and sticks of sulphur as indicators are used to advantage. A different class of leaks is that where the joints are directly in contact with water or brine. To ferret out leaks of this character, the use of either litmus paper or Nessler's solution is necessary.

Higher Boiler Pressures—Opinions of Distinguished Engineers

FRANCIS HODGKINSON, Turbine Engineer, Westinghouse Machine Co., Pittsburgh, Penn.: It is unfortunate that we cannot jump immediately to 600 lb. together with 100 deg. superheat or to some similar pressure and superheat, and determine once and for all with the greatest dispatch the commercial feasibility of such high pressure. You would not want to risk your reputation on such a step, and neither would I.

It seems that the only difficulty in the way of these high pressures is the boiler. There are very few boilers now on the market of a design that is suitable for such a jump in pressure. Why not some form of flash boiler? There is no difficulty in designing turbines to care for such pressures and superheats. It simply means the use of heavier parts for the extremely high-pressure end of the turbine, and this would be for a comparatively small part of it, because the pressure would necessarily be dropped very quickly; that is, in a few stages. The cost of the turbine would of course increase somewhat, but this would not be a significant increase. After considering every phase of the question, one concludes that inasmuch as there is a theoretical gain of 10 to 12 per cent. to be had by increasing the pressure, and further, as it is possible with materials to design equipment to care for such pressures and temperatures, it is important that we try to obtain the gain to be had.

As the River Station of the Buffalo General Electric Co., described in the leading article of this issue, likely portends much for the future of higher boiler pressures, and because of the widespread interest in the economies theoretically possible by going to pressures as high as 600 to 1000 lb., the author of the article referred to requested some distinguished engineers to express their views on the possibilities and limitations of such pressures. It is to be regretted that the late Henry G. Stott, who acted as consulting engineer for the owners during the design and construction of the Buffalo plant, was unable because of his illness to contribute to the symposium.

SAMUEL INSULL, President, Commonwealth Edison Co., Chicago, Ill., refers us to the following opinions on the subject expressed in various addresses: The improvement in the efficiency of prime movers in the last few years has been upward of 35 per cent., and I am strongly of the opinion that in the next few years, probably by the adoption of very much higher steam pressures, we shall obtain still greater improvement.

It is not at all beyond the range of possibility that eventually, and indeed in our own day, we shall be operating steam turbines with the aid of boilers carrying as high as 1000 lb. pressure. There should not be any great obstacle to the achievement of the efficiency that would come as a result. It would seem to me that this is a good deal nearer today, relatively speaking, than the steam turbine was not so many years ago, when we depended on cruder and less efficient forms of prime movers.

At the present time about 35,000 to 40,000 kw. is the largest size that can be obtained. I have heard of some orders being given for 50,000-kw. machines. I am rather sorry to hear it, because I think the buyers will regret it. Before we need the larger size, we will need higher boiler pressure, which will first require expensive experiments in boiler construction, and we will need many changes in the details of apparatus used in connection with large turbine units; and I think that the progress of the next few years will be the better made if it is the slower made.

R. J. S. PIGOTT, Power Superintendent, Remington Arms and Ammunition Co., Bridgeport, Conn.: The greater the heat drop the greater the thermal efficiency. This gives two extremes—pressure and superheat at the one end, and vacuum at the other. The limit in vacuum is practically reached, as a vacuum amounting to 97 per cent. perfect may be maintained if the proper equipment available in the market has been selected and attention is paid to air leaks. As regards the higher pressures and superheat, the characteristics of metals employed prohibit the use of higher temperatures than about 700 deg. F. I do not believe that the Germans have been able to do any better than we in bringing forth metals that can commercially compete with those now used and which are more suitable to the temperatures contemplated and discussed for power plant work. Regarding the turbine, I do not look with much favor upon an exceedingly high pressure, say 600 lb., with the comparatively low superheat of 100 deg. for the reason that the most serious windage and friction loss in the turbine occurs in the high pressure stages; reducing the superheat would advance the dew point well into the high-pressure stages, resulting in losses with which everyone is familiar.

Relative to the low efficiency of the high-pressure end of the turbine, it is of interest to know that the first wheels of some of the 30,000- and 35,000-kw. units at various plants have an efficiency of but 48 per cent., while that of later wheels, single-velocity stage, increases to 70 and the last to 80. It is true that much of this apparent loss in the high-pressure stages is recovered toward the low-pressure end of the turbine by reason of the increased heat drop available, but one must remember that these losses are never fully recovered. The advancing of the dew point further up into the turbine would, of course, tend to serious losses due to wheel friction. With such a dense medium, the eddy losses are bound to be greater than at lower pressures.

It is not likely that there will be any appreciable reduction in pipe sizes because of the use of pressures up to 600 lb., as the friction losses increase very rapidly with the density. Distortion and thrust due to expansion and contraction are so serious now with pressures of only a little above 200 lb. and with not over 150 deg. F. superheat that new designs of expansion joints seem vitally essential to tight and safe pipe work.

All in all, it will likely be found that the operating difficulties at a pressure of 600 lb. with 100 deg. F. superheat or thereabouts will be so serious as to overcome the advantages that might accrue from the low water rate.

While a boiler plant may be designed for a normal steam temperature of 600 deg., it is a certainty that the temperature may rise at times to 700 deg. or 750 deg., due to forcing of boilers, which naturally increases superheat, and to sudden loss of load at high rates of driving, resulting again in excessive temperatures of the steam.

R. H. Rice, Engineer, Turbine Department, General Electric Co., West Lynn, Mass.: It is undoubtedly a fact that plant efficiency can be increased by the use of high steam pressures and high superheats. The use of notably higher steam pressures and superheats than are now customary involves some development. It is likely that some experimentation will produce results which would thoroughly warrant the endeavors. I am heartily in favor of all propositions that tend toward an increase in the limits of steam pressure and of temperature of steam above those now used in power stations.

High Pressures Well Suited to 24 Hr. Service

It must be recognized, however, that in attempting to use high temperatures it is necessary to expend a certain amount of heat at each starting of the plant to heat up the complete apparatus. This requires a considerable number of heat units and appreciable time. Therefore the use of high temperatures of steam is most beneficial in plants that operate on a 24-hr. basis. Plants operating only a few hours and then cooled off use appreciable quantities of heat in this preliminary heating up.

With proper regard for the usefulness of high temperature and high pressure, our plant operators should find a distinct gain from their adoption, and the difficulties to be surmounted are, in my opinion, comparatively slight and can be overcome with a reasonable expenditure of time and money.

L. C. Loewenstein, Turbine Department, General Electric Co., West Lynn, Mass.: We are at present prepared to handle temperatures up to 800 deg. F. for any customer who is desirous of going to the extreme of high pressures and high temperatures in order to secure the highest economies possible.

Frederick Sargent, of Sargent & Lundy, Consulting Engineers, Chicago: The Northwest Station of the Commonwealth Edison Co., Chicago, was built some six years ago for 250 lb. pressure and 200 deg. F. superheat. Since that time we have been trying to raise the pressure to 500 or 600 lb., and both the General Electric Co. and the Westinghouse Machine Co. claim there will be no trouble about building a turbine for this pressure. They also say they could go up to 700 to 750 deg. F. of total temperature.

We had the Babcock & Wilcox Co. undertake the design of boilers and steel economizers to meet the foregoing conditions, but when the plans were fully developed for the boilers, we found they were not only very costly, but it seemed to us that the type of boiler ought to be altogether changed for higher pressures, and we are now laboring with several people, including the Babcock & Wilcox Co., investigating types of boilers suitable for higher pressures.

On account of the difficulty of getting proper boilers, we have had to give up the matter for the present. The war, of course, has increased the difficulty of getting this boiler matter properly developed. In the meantime we had to go ahead with important work and decided to use the highest pressure that the present type seemed to warrant without running into too much experimenting.

We decided to put in boilers for the Joliet (Ill.) Station of the Public Service Co. for 350 lb. pressure and 225 deg. superheat. Those boilers are of the same general type used in what is considered the most modern stations in Europe. The economizer is placed on top of the boiler sections, above the superheater, and, together with the boiler and superheater, is wholly inclosed in a steel envelope.

The first plant to be designed in this way, that I know of, was at Eberswalde, Germany, about 30 miles north of Berlin. I looked over the plant when it was first put in operation and some two or three years later went back to make a more careful examination and to see the effect of the gases on the tubes of the steel economizers. Since then several boiler plants of this type have been installed, the most notable being that of the Victoria Falls Power Co., South Africa, which supplies power to the Rand mines. This was engineered and installed by the A. E. G. Co., of Berlin.

One of the tramway companies in London has an installation of this type, and I think two or three other important plants of the same design have been built in England.

At the works of the General Electric Co., Rugby, England, there is one boiler of this type coupled directly to a steam turbine of about 3000 kw. capacity. This boiler was put in operation about three years ago to determine results with high pressure and high superheat, and I went to Rugby at the time to see some tests made. The particulars of the boiler as contained in my notebook are as follows:

Test Pressure 525 Lb.

Boiler-heating surface, 3180 sq.ft.; economizer-heating surface, 1946 sq.ft.; superheater surface, 1462 sq.ft.—making a total of 6588 sq.ft. Two chain grates were used in the furnace, the total grate area being 105.5 sq.ft. The working pressure was 350 lb., test pressure, 525 lb.; total steam temperature, 700 to 750 deg. F. Capacity contracted for was 18,000 lb. of steam per hour, and the guaranteed efficiency was 80 to 82 per cent. of the net calorific value of the fuel.

All the boilers of this type, including those in Germany, are from the Babcock & Wilcox Co.

You will see from the foregoing that our Joliet plant is not new by any means, either from the point of view of pressure or of total steam temperature. The type of boiler and the general features of construction are at least five or six years old.

I may here mention that in my early days there was erected somewhere on the Clyde a Perkins boiler and engine that had a working pressure of 600 lb., but I understood it was a failure, owing to the difficulty of taking care of the construction for such pressures at that time. If you could unearth the information about this Perkins boiler and engine, it would make interesting reading at this time.

We are using welded steam joints in our flanges and valves in several of our latest jobs. The 35,000-kw. unit

installed at Northwest Station of the Commonwealth Edison Co. has the joints of all steam piping, valves and fittings welded, but they are not welded with the idea of holding them together—that function is performed by bolts as formerly. We merely make a thin weld inside the bolt circle to seal the joint. I am sending you a sketch showing this type of construction. It has proved very satisfactory. (See illustration.)

We have great confidence in the economy that will eventually result from the use of high initial working temperatures and pressures. Of course the high temperature can be obtained by low pressure and high superheat, but the economy will be greater if both the superheat and the pressure are high. The only limit at present is that given us by the manufacturers of the machinery. If metals can be developed that will stand still higher temperatures, we hope to get still better economies.

Superheat High Pressure Exhaust

Please note that the high initial temperature is not the only line of advance; the raising of the average temperature is another advance, distinct in itself. This can be done by superheating the exhaust from the high-pressure end of the turbine before it enters the low-pressure end. This in combination with the high initial temperature will give a very high average temperature, which is, after all, the important thing if the highest economy is to be realized.

When this is all done and provided we can maintain the present boiler, superheater and economizer efficiencies, it can be easily shown that a kilowatt-hour can be put on the switchboard for one pound of high-grade coal.

Anybody who can advance this matter in any substantial degree will always receive a warm welcome from us.

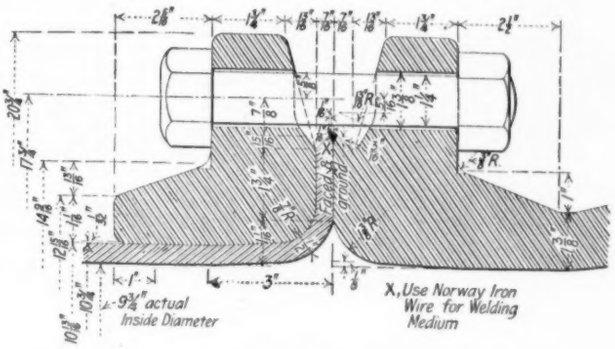
Edward F. Miller, Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.: It is my belief that in the not very distant future many new plants will be designed for pressures approaching 600 lb. I know of one plant near Boston which has been considering such pressures. Certain safety-valve manufacturers have had requests recently for steam safety valves for boilers carrying this pressure, and one concern has filled orders for such valves.

Sebastian Z. de Ferranti, Hollinwood, Lancashire, England: I am so fully occupied at present that I cannot give sufficient thought to the questions which you raise to write on the subject. I can, however, say that I am fully satisfied that we must work much higher pressures and temperatures to get the greater economies which modern conditions of power generation demand. There are, of course, great practical difficulties to be overcome to enable us to do this, without corresponding disadvantages in the way of breakdowns and higher maintenance costs.

I have no doubt, however, that the necessary experimental and pioneer work will be done, and that by means of higher pressure and higher temperature, we shall in the near future generate power much more economically and so help to compensate for the enormous waste of resources now taking place.

William D. Ennis, Professor of Mechanical Engineering, Polytechnic Institute, Brooklyn, N. Y.: Because it is not a spectacular but a steady development, the tendency toward higher steam pressures and temperatures is impressive. Pressures increased at a fairly uniform rate up to nearly 200 lb. Attention was then given to superheat. After a pause, there is now renewed interest in increasing steam pressures. For many years locomotives have employed pressures higher than those of stationary plants. The results have been strikingly favorable to efficiency. Ten years ago the compound condensing steam engine of the White motor car, with pressures up to 595 lb. and superheats up to 300 deg., gave a horsepower in the cylinder on 10.8 lb. of steam per hr.

The turbine is particularly adapted to utilize high initial pressures, because the increased efficiency due to such pressures is greatest when the ratio of expansion is a maximum. Thermodynamic considerations favor high initial pressure rather than high superheat as essential to efficiency. Thus, with 1 lb. absolute back pressure and 487 deg. steam temperature, the efficiencies of the so-called Rankine cycle work out 0.35, 0.33 and 0.30 for steam pressures of 600, 400 and 200 lb. respectively. At the pressure first named the steam is initially saturated; at 200 lb. pressure it is superheated 105 deg. With saturated steam the cycle approximates closely to the ideal cycle of Carnot. With superheated steam the departure from the Carnot cycle increases with the amount of superheat. Under the foregoing conditions the Carnot cycle has an efficiency of 0.42. At 600 lb. pressure the Rankine cycle has an efficiency $0.35 \div 0.42 = 0.83$ that of the Carnot, while at 200 lb. pressure this ratio is only $0.30 \div 0.42 = 0.71$. There is probably no other heat engine whose cycle is so nearly equal in efficiency to that of Carnot as the steam turbine.



THE JOINT IS FACED, GROUND, AND THE TIP EDGE WELDED

Unfortunately for the case of high pressure, pressures must be exceedingly high in order to get a temperature range even reasonably good. In modern plants using superheat, steam temperatures around 550 deg. are common. To obtain this with saturated steam would involve a pressure of 1062 lb. per sq.in. A compromise is therefore necessary. The pressure is made as high as is practicable with the mechanical limitations imposed. This gives an efficiency close to that of Carnot, up to the temperature of saturation. Superheat, with the high pressure, further increases the efficiency, though not so rapidly as the Carnot efficiency increases.

There are further reasons why, with high pressures, superheats must be high in proportion. The frictional losses in a turbine are proportional to the density of the steam. High pressures increase the steam density and the friction and therefore tend to lower the efficiency. Superheating, at any pressure, decreases the density.

Again, with a fixed exhaust pressure, the expansion of dry steam leads to greater liquefaction as the initial pressure is greater. Particles of moisture, due to liquefaction, cause friction and wear and may be a source of danger. The preventive of this is superheat. For a given back pressure the necessary amount of superheat increases as the initial pressure increases.

High Superheat Desirable

It is therefore logical that the recent tendency toward seriously increased steam pressures should be accompanied by a tendency toward maintaining or increasing prevailing superheats. How far this will go is a question impossible to answer. Up to the present, practice in this country has seldom gone above 200 lb. steam pressure with 200 deg. of superheat. This implies a steam temperature of 582 deg., above which safe working stresses on materials are lowered. The very high superheats used in Europe before 1870 were employed with what would now be considered absurdly low pressures. Yet in the European practice of the last five years steam temperatures up to 1000 deg. have been, if not common, at least commercially handled, particularly in the locomobile.

Increases in either steam pressure or temperatures will no doubt stress our resources in design at many points. Boilers with small water tubes will probably be suitable with only minor modifications up to 350 or 400 lb. They will operate at reduced efficiency on account of the increased stack temperature necessarily following increased steam temperature. Economizers may therefore become standard equipment with us, as they are now in Continental Europe.

As to engines, Diesel engines regularly use 550 lb. compression, and many of the modern of the hot-bulb semi-Diesel engines, with 300 lb. compression, realize about 550 lb. maximum pressure, which is a sudden pressure.

Piping will demand serious attention—it demands it now. The welded joint will help if mechanically perfected. Expansion will be greater than it is now. This may be taken care of by a more concentrated arrangement of boilers and turbine. On the other hand, with increased superheat increased velocities will be permissible: the greater efficiency of the turbines will lead to a reduced weight of steam; and the higher pressure will tend to increase the steam density. All three considerations will lead to the use of pipes even smaller than those now employed, and this will help us to meet the stress and leakage conditions which threaten trouble.

Several 350 Lb. Pressure Boilers Building

The Babcock & Wilcox Co.[2]: Gage pressure of 200 to 225 lb. at the boiler with a superheat of 150 deg. F., may be said to be average present practice in power-station boiler plants. Comparatively recent developments in the design of steam turbines for large plants and of some types of reciprocating engines for small plants make higher thermal and consequent higher over-all station efficiencies available by the use of higher boiler pressures and higher degrees of superheat.

This company now has in course of construction a number of large boiler units for 350 lb. working pressure with 250 deg. F. superheat, which follow our standard designs and which are turned out as a heavier, standard, manufactured product and not as a special construction.

[2]From the Prime Movers Committee Report, 1916, National Electric Light Association.

Recent inquiries from customers regarding boilers for 500 to 600 lb. working pressure, with the steam superheated to 700 deg. F., have prompted us to institute a series of experiments which, while not yet completed, have advanced sufficiently to demonstrate that if the demand for such a boiler is large enough, it can be manufactured and turned out as standard commercial apparatus.

For 350 lb. working pressure the cost of the larger-sized units would probably be about 20 per cent. more than the cost of boilers of present standards for 200 to 225 lb. working pressure. Our estimates for boilers of 500 to 600 lb. working pressure have not as yet advanced far enough for us to determine the additional cost per unit.

The question seems to be whether 500 to 600 lb. steam pressure with the practical limit of 700 deg. F. temperature will, as compared with 350 lb. working pressure and 700 deg. F. temperature, sufficiently increase over-all station efficiencies to compensate for the difficulties incident to the higher pressure to be overcome between the boiler and the prime mover.

In short, assuming 700 deg. F. as the practical limit of steam temperatures, the problems to be solved, incidental to the higher boiler pressures, are probably entirely outside of the boiler and furnace.

An Insurance View of Higher Pressure

S. F. Jeter, Chief Engineer, The Hartford Steam Boiler Inspection & Insurance Co.: The insurance engineer looks at such propositions largely from a safety standpoint and is not particularly concerned with the question of increase in economy that may be possible from radical departures from standard practice. The mere increase in pressure would not in itself be a great menace to safety because it is a simple matter to build boilers of any required strength, and therefore the factor of safety could be kept the same no matter what the working pressure might be, so long as there were only pressure conditions to consider.

However, most destructive boiler explosions and possibly a majority of the minor failures of boilers are occasioned by a gradual weakening of the parts rather than a failure of the structure caused by the direct strains placed upon it. While there is no justification for assuming that such gradual weakening is caused alone by the contraction and expansion of the parts, there is no doubt but the strains set up by this means are a contributing factor in most cases of failure. Assuming a normal temperature of 70 deg., an increase in working pressure from 150 lb. to 500 lb. would increase the temperature range to which the parts of a boiler were subjected about 35 per cent. Therefore any tendency to greatly increase the working pressure is likely to cause an increase in failures of such apparatus.

Another factor to be reckoned with in considering the safety of high pressures is the increase in the stored energy. A cubic foot of water at 100 lb. pressure contains 812,000 ft.-lb. of energy that is released and becomes available for the destruction of surrounding property when an explosion occurs. At 500 lb. pressure the same amount of water would contain 2,344,340 ft.-lb. of such energy. It is readily seen that by releasing the energy in a fixed amount of water, the results of an accident with the higher pressure are likely to be considerably

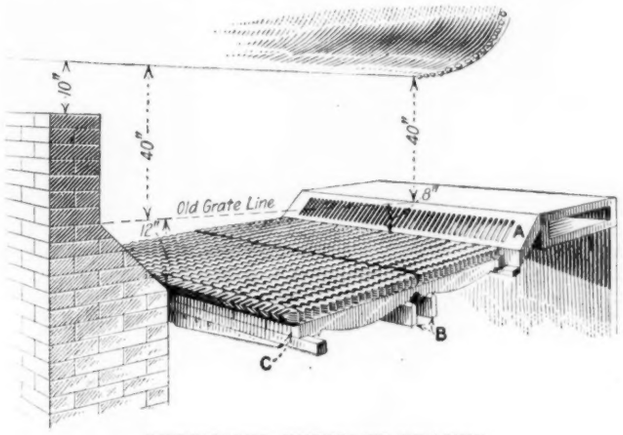
more serious than with the lower pressure. It is true that boilers intended for very high pressures are usually so constructed as to contain a relatively small amount of water per horsepower, although some of the worst explosions in the annals of steam boiler history have occurred with boilers constructed along these general lines, indicating clearly that any boiler which contains sufficient water to make it practical and serviceable, is likely to contain sufficient energy stored in that water to cause a very disastrous explosion if liberated under favorable circumstances.

In the payment for damages resulting from explosions the insurance company becomes vitally interested in the possible damage that may result in the event of an accident, and from this viewpoint an increase in pressure also tends to increase the hazard which should be met by a compensating increase in the rate for insurance.

It has been demonstrated by a number of years of practice that the handling of superheated steam is accompanied with considerable difficulty, and the difficulties apparently multiply very rapidly at the higher temperatures. Some twelve or fourteen years ago many engineers recommended very high superheats, but owing to the difficulties experienced in conducting the steam and in its use, such temperatures were abandoned. It has been commonly accepted among engineers in the past that any degree of superheat beyond that required to deliver dry steam to the power developing apparatus was not of particular economical advantage, and to avoid the troubles experienced in transmission and use of such steam, superheats exceeding 125 to 150 deg. were rarely used.

Budd Depressed Furnace Grates

In many boiler plants the grates are set too close to the boiler shell, and where soft coal is used, there is not room above the fire bed for the proper distillation of the

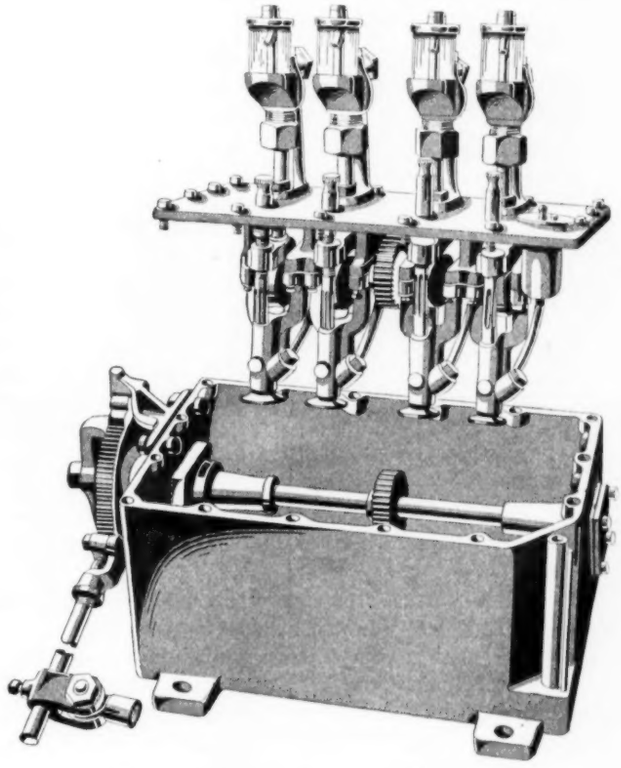


DEPRESSED FURNACE GRATES

gases. The space between the grate surface and the boiler shell should be at least 48 in. The illustration gives an idea of how the grate surface may be lowered and additional combustion space gained if the complete resetting of the boiler is impracticable. This grate is built by the Budd Grate Co., New York and Philadelphia. In the illustration, *A* represents the depression plate; a hand-regulated shutter controls the air passing through it. Upon this depression plate the grates rest. The two center bearers *B* are ventilated so that air has access to the center ends of the grates. At the bridge-wall there is an anticlinkering fork *C* that allows air to pass close to the bridge-wall and prevent its deterioration, and also prevent the formation of clinkers at the back of the furnace. The grates pitch toward the rear, and the bridge-wall is designed to cause a baffling effect for the gases of combustion, so that the gases are thrown back over the fire before going to the combustion chamber.

Invincible Oil Pump

Accessibility of a machine is a feature that appeals to an engineer, and it is almost as essential in the design as it is to make the parts to work together. One feature



DETAILS OF THE PUMP CONSTRUCTION

of the "Invincible" mechanical oil pump, manufactured by the Lunkenheimer Co., Cincinnati, Ohio, is the accessibility that is had, as shown by the illustration. Practically all parts are attached to the lid, so that upon removing it the parts are also removed from the pump case. The pump is operated by a ratchet that revolves in the pump case, on the shaft of which is a gear that meshes with an eccentric shaft gear that imparts motion to the pump plungers. Auxiliary plungers are connected with forced-feed plungers and move in unison with them. On the upstroke of the auxiliary plungers oil is drawn through strainers in the bottom of the holders into the auxiliary plungers, from which it is forced on the downward stroke through tubes and passages to the sight-feeds. As the oil drops through the sight-feeds, it is drawn into the force-pump cylinder on the downward stroke of the plungers and is forced on the upward stroke to the engine cylinder. The quantity of oil fed is regulated by an extension of the auxiliary pump plungers. Independent feed regulation for each outlet is also provided. This pump is made with from one to four feeds.

Protecting Electric Machines Against No-Voltage

By H. M. Phillips

SYNOPSIS—Consideration is given to the different schemes of no-voltage protection, their care and abuse and the necessity of keeping this device in good working condition.

Practically every direct-current motor and a considerable number of alternating-current motors have their starters equipped with a "no-voltage release" device which is supposed to open the circuit upon failure of the voltage. As a rule there is very little attention paid to the reliability of this device when it is installed and still less to keeping it in good condition afterward. To demonstrate this statement, go into almost any plant that has a considerable number of direct-current motors and observe the operation of the no-voltage release when the motor is being shut down—not by pulling the starting handle to the "off" position, but by opening the line switch. In a large number of cases one or all of the following conditions will be found: Failure to release at all; failure to operate until the motor is almost at a standstill; failure to cut the current completely off, the controller returning part way to the "off" position. In the majority of cases no very serious damage will occur from such failure, but in the exceptional instance there is the possibility of such serious damage that it is well-worth guarding against.

Direct-Current Motor Panel-Type Starter

The ordinary panel-type starter, used on direct-current motors, where the starting arm is moved over a row of contacts against the pressure of a spring and retained in the final position by a small electromagnet, is probably the worst offender. When first put in, the contacts are smooth and coated with vaseline. This lubricity is not likely to be renewed very frequently, consequently, the contacts become roughened with use and more or less dirt collects, which makes the arm operate so hard that the spring has not power enough to return it to the "off" position when no longer held by the magnet. Consequently the motor is left connected directly across the line, which is practically a short-circuit. If all goes well, the returning current will blow one or more fuses or circuit-breakers and do no further damage; it is hard to predict how far the damage may extend when all does not go well. Similar results may be produced by the careless operator, who fails to make sure that the starter is in the "off" position before closing his switch. The same fault is likely to cause the arm to return only part way to the starting position; if only one or two points, the probabilities are that the fuses or circuit-breakers will go, when the circuit is made alive with very little chance of more extended damage. But let the arm travel a little farther, and the motor may start up on the return of current. The starting resistance is only designed to carry the motor current during the ordinary period of starting; therefore, unless someone comes to the rescue within a few minutes, the starter will be burned out. In these days of "safety first" there is an even more important consideration: Someone, who ought to know better, takes the opportunity of the shutdown to make adjustments or repairs to the machinery; consequently, if the motor starts without warning, a serious accident may occur.

When the starter is new, the surfaces of the magnet poles and the metal part of the starting arm which they engage are somewhat rough, and may have a small piece of copper to prevent an iron-to-iron contact. With use the roughness disappears and the copper, if there at all, is flattened out so as to give less separation or may become detached. As a result residual magnetism is much more pronounced than it was at first and, aided perhaps by the conditions previously mentioned, may hold the arm in place after the line is dead. As a temporary expedient glue a piece of paper on the poles of the magnet.

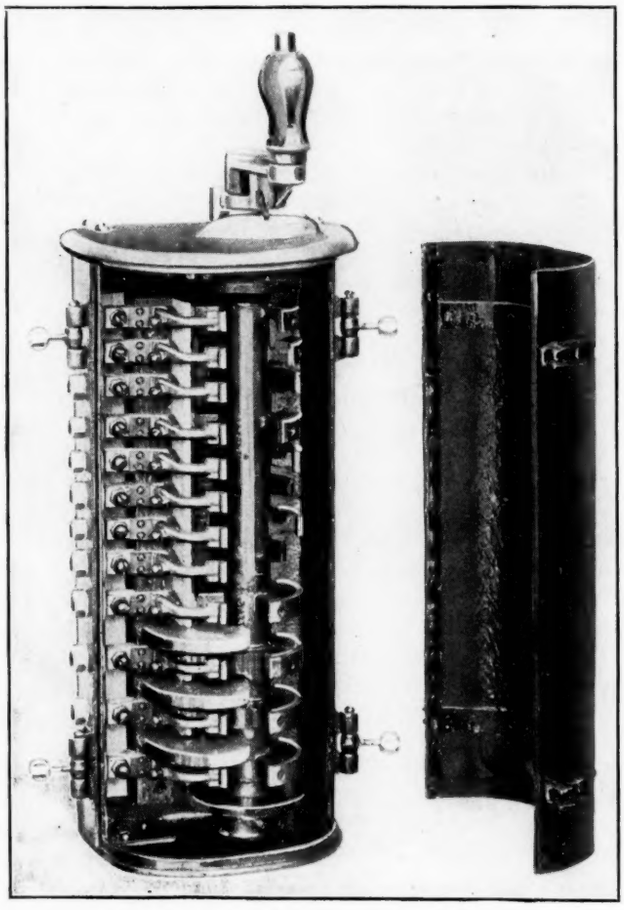


FIG. 1. DRUM-TYPE CONTROLLER

Failure of voltage is quite likely to have arisen from the opening of a circuit-breaker in the power house, but the line does not become dead the moment that the breaker opens; there will be a pressure on the motor circuit as long as the motor continues to revolve. The voltage will return at its full value the instant that the engineer closes the breaker, which he will probably do as quickly as possible. If a low voltage is sufficient to cause the no-voltage release to hold in, it will not let go

until the motor armature is nearly stationary; or it may even hold after the armature is stationary, on account of the voltage generated by another motor that is still moving. The return of voltage at this critical moment will have the same effect as if the release mechanism had been held in by any other means. It may also be a reasonable assumption that when an exceedingly low voltage is sufficient to make the magnet hold, a very slight increase in friction, or a slight increase in the residual magnetism, would be sufficient to cause it to hold after the voltage had entirely disappeared. In many cases the best remedy would be to weaken the magnet by removing some of the turns from the coil, or glue a piece of paper on the polepieces of the holding magnet, as previously described.

Circuit-Breakers with No-Voltage Release

A drum-type controller, Fig. 1, seldom has a no-voltage release incorporated in it. In some cases it is assumed that there will always be an operator near at hand who will turn the controller to the "off" position as soon as the voltage fails. It is easy to see that this is a rather unsafe assumption in nearly all cases and entirely unwarranted in many. Such a controller, or starter, is usually provided with an external switch and circuit-breaker, so that the careless operator may close the switch while the starter is in the "on" position and throw the motor directly across the line. Partial protection may be obtained by the use of a circuit-breaker provided with a no-voltage release attachment, which will trip the breaker on failure of the voltage. This alone does not prevent the breaker being closed while the starter is in the "on" position. Such a breaker is generally provided with a small magnet, connected across the line, which, when voltage fails, releases a weight or armature that strikes the holding catch of the breaker a blow similar to that given when tripped by an overload. Here also are possibilities of failure. The weight must be heavy or the spring strong, in order to insure tripping when the catch becomes slightly stiff through wear. The magnet in some cases is not strong enough to pick up the weight after it has fallen, and it must be lifted by hand in order to close the breaker; while in others (a better form) the opening of the breaker lifts the weight to a position where it will be held when current comes on the line. Other conditions will be found where, although the breaker opens on no-voltage, it is possible to close it again and leave it closed before current comes on. The magnet does not hold the weight, but lacking the impact that results from its falling freely, the dead weight, or spring tension, is not sufficient to trip the breaker.

A more reliable arrangement is the use of a switch or circuit-breaker that is closed and held closed by a magnet or solenoid. For operation on overloads a second coil operates a plunger that opens the holding-in magnet-coil circuit. This switch may be closed by a small "pilot switch" at any desired point. In order to obtain full protection the pilot switch should be omitted in favor of a specially provided contact inside the controller, which will close the holding-coil circuit only when the control handle is in the "off" position. The switch can be made so that when closed it will establish another contact and allow the holding current to continue to flow when the controller handle is moved.

As the switch described in the foregoing must act both as circuit-breaker and no-voltage release, it is very important that there should be no uncertainty in regard to its opening. As usually constructed, there appears to be little opportunity for mechanical friction; although where the plunger of a solenoid is a fairly close fit, as is quite commonly the case, there may be a possibility of its becoming clogged with dust or other foreign matter. The clapper switch, where a magnet is used in place of a solenoid, appears to offer less opportunity for friction.

Some magnet switches are so arranged that, at the instant the closing operation is being completed, the motion of the switch opens a contact and introduces a considerable resistance in series with the holding-in coil, which reduces the current to an amount just sufficient to hold the switch securely. This arrangement not only allows the switch to open on a comparatively small reduction in voltage, but also greatly reduces the amount of power required to hold the switch closed and allows the coil to work at a low temperature. The various forms of automatic controllers, for operating motors from push-button stations or by the manipulation of a small master controller almost invariably have their main circuits opened and closed by magnet switches similar to those described in the last paragraph and consequently open the circuit on failure of voltage, with the possibilities of failure which have already been described. One type of push-button station is shown in Fig. 2.

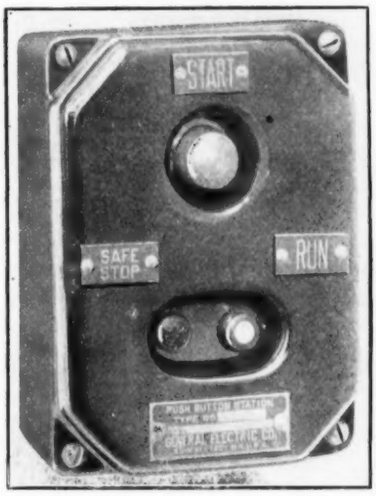


FIG. 2. PUSH-BUTTON STATION

The fact that a resistance is placed in series with a magnet switch does not necessarily mean that the switch will open with a comparatively small reduction of voltage. This is the case only when the extra resistance is cut in at the instant the switch closes. Many magnet switches are provided with an external resistance. This construction admits of the possibility of opening the switch by short-circuiting the magnet coil instead of by opening its circuit. Although this is a convenient method for application to certain special equipments, it is not a very desirable one. A poor contact may cause the switch to remain closed when it is urgently needed to be open; even a slight increase in the resistance of the short-circuiting contacts may leave enough voltage on the coil to keep the switch closed.

To Test the Polarity of a Direct Current—Moisten a piece of litmus paper with a weak solution of sodium sulphate, touch the ends of the two conductors to the moistened part; where the positive conductor touches, the paper will turn red, and where the negative is placed it will turn blue. The litmus paper should be laid on glass or some other nonconductor.

In Making a Hydrostatic Test on a boiler in service (not a new boiler) the A. S. M. E. code states that the test pressure shall be 1½ times the working pressure. During such tests the safety valve or valves must be removed or each valve disk held to its seat by a testing clamp and not by screwing down the compression screw upon the safety-valve spring. The Massachusetts rules also specify 1½ times the maximum allowable working pressure when making a hydrostatic test.

Steam-Engine Troubles—Dashpots

By H. Hamkens

SYNOPSIS—The seventh of a series of illustrated articles on steam-engine troubles. This one deals with many types of dashpots, the troubles they are heir to and how to overcome or minimize such troubles.

An engineer can often perceive by the sound of the dashpots when something goes wrong with the engine. There is no such thing as a noiseless or soundless dashpot, although some builders may be found who claim that they have them.

An old-time style, still in use on many engines, is shown in Fig. 93. It represents the original vacuum dashpot, the object of which is to create a vacuum in the lower chamber by having the valve gear lift the plunger, and to let the atmospheric pressure force it down again as soon as cutoff takes place. If there is no leak, the force to push the plunger down will be constant for any lift, whether the cutoff is short or long; the pressure will be equal to the area of the plunger in square inches multiplied by the atmospheric pressure. Air in the lower chamber will weaken the action of the pot. To keep it out the plunger must fit well, it should have a number of grooves cut in which, when filled with oil, will act as packing. A small snifting valve *A* should

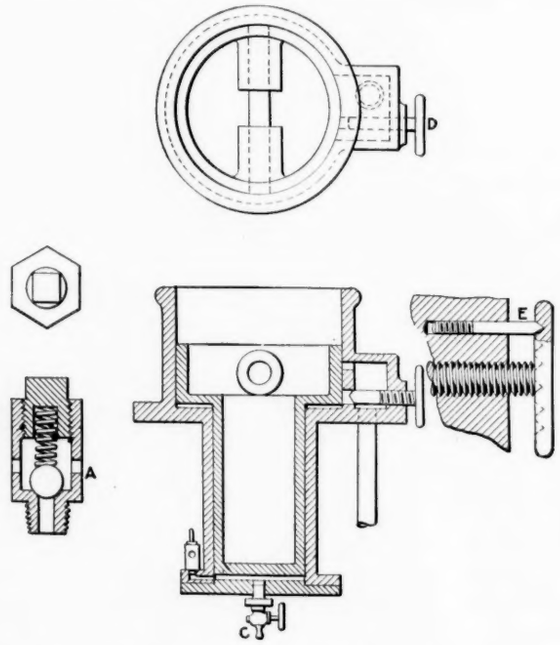


FIG. 93. AN OLD-STYLE DASHPOT

be provided to relieve the pot of air that may pass below the plunger; the little ball valve, shown in detail, which may be made of a piece of hexagon steel or bronze, will answer the purpose. No oil should be allowed to accumulate in the bottom of the pot; it must be discharged either through the valve *A* or through a pet-cock *C* in the cover. The upper chamber and the large part of the plunger act as a cushioning device for the dashpot in the following manner: Air is drawn in by the ascending plunger through a slotted opening in the side of the pot and on the downward motion is discharged freely until the lower edge of the plunger passes the slot; from that moment cushioning takes place, the confined air being compressed and forced out through a hole near the bottom of the upper chamber, which can be opened or closed as required by the screw *D*, the little check *E* consisting of a round pin inserted in a hole in the air chamber on the side of the pot and forced by a spiral spring into a countersunk hole drilled into the inner face of the handwheel, which keeps the screw from turning on its own account. The principle of this pot is all right, but its action leaves much to be desired. The pot is open at the top, and being placed near the floor, it is almost impossible to keep out grit and dirt, which will wear out the pot and impair its

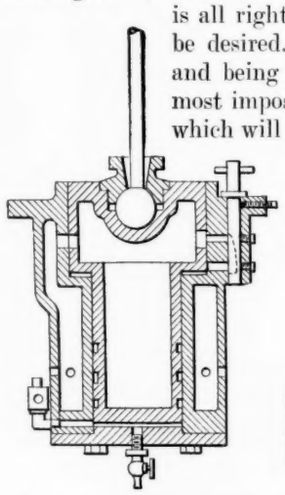


FIG. 94. AN IMPROVEMENT OVER FIG. 93

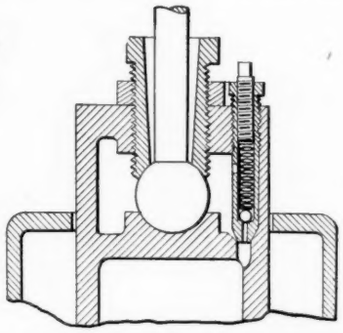


FIG. 95. NOTE THE SNIFTING VALVE

action. The pin in the upper part of the plunger for the dashpot rod is a detriment; if the pot is not in line with the valve gear, the dashpot rod stub end will tend to force the plunger over and reduce the quick action desired for good steam distribution and a quiet-running engine. The old rule was to make the diameter of the large part of the plunger twice the size of the small part, which makes it heavy and sluggish in action.

The troubles with the old open dashpot have been overcome in the design shown in Fig. 94. The ratio between the diameters of the plunger has been reduced, and the plunger has been extended to the top of the cushion chamber, preventing dirt dropping into it; the dashpot rod is held in place by a ball joint, eliminating friction due to bad alignment. The air for the cushion chamber is drawn from an annular space around the vacuum pot which, having a number of small holes drilled in the outer shell, acts as a silencer. The cushioning valve is operated by a handle, a slight turn of which will change the effect to suit. The snifting valve and drain-cock are in the bottom of the pot. This kind of dashpot will give good results if it is kept in first-class order.

Care should be taken to remove every particle of core sand from the inside of the plunger and the annular space of the pot; if this is neglected, there may be trouble if the vibrations in running shake it loose so that it can work its way between the working surfaces of the plunger and the pot.

Fig. 96 represents what is called an inverted dashpot, in which the plunger is stationary and the pot moves. A removable cap makes the cushion chamber accessible. This kind of pot is practically dust proof. A little snifting valve is located on top of the stationary plunger—a bad place for it. Anything that obstructs this valve puts the pot out of service, and the whole apparatus has to be taken apart to remove the obstruction, which means a shutdown. Some kerosene squirted in through the pet-cock will sometimes wash it out. This dashpot seems to be constantly out of order; the plug gets loose and changes its position, making the action of the pot uncertain. There is no adjustment on the ball joint for the dashpot rod; if the ball wears and becomes loose, the nut must be taken off and reduced at the bottom by filing. These little imperfections on a thing that is otherwise all right are annoying.

Fig. 95 shows a way to overcome the trouble with the snifting valve, pet-cock and adjustment of the ball and socket. The top of the pot is enlarged and a thread cut inside a hole in it instead of on the outside, as in Fig. 96. A screw with a hole for the dashpot rod is screwed in. A check nut will hold the screw tight in place, and any wear or play in the ball joint can be taken up without difficulty. The enlarged head serves also to receive a combination snifting and air valve, which controls an opening to let in air, oil or kerosene,

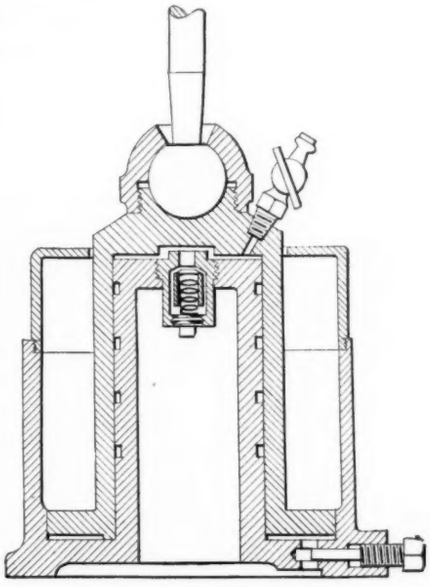


FIG. 96. THE INVERTED DASHPOT

as required. Air made to enter and leave the pot through this valve passes through a chamber that surrounds the ball, thus preventing noise which it would make in passing through a pet-cock.

The inverted dashpot has an advantage over the first two pots described, inasmuch as it has a large outer casing that forms a natural reservoir for the air used in cushioning. No new supply from the outside is needed; the same air is used over and over again. As shown in Fig. 96, the pot has a turned flange at the bottom which performs the cushioning part by dropping into a bored recess of the casing. The sides of the casing slant toward the recess into which the flange is fitted, so that the cushioning takes place gradually. The screw at the bottom, which regulates the cushioning, is troublesome. It has a square head for adjustment by a wrench. This is unhandy, since the wrench is frequently mislaid. A knurled handwheel with a simple check would save a lot of trouble. Air and oil are discharged from the cushion chamber below the floor through a small hole in the bottom.

Another inverted pot is shown in Fig. 97. It has no ready adjustment for the ball-and-socket joint, the cap being held on by tap bolts. The cushion chamber is not recessed; air is drawn in through little ball check valves in the bottom which are liable to get out of order by dirt or gummy oil getting into them. It is evident that a partial vacuum will be created in this chamber every

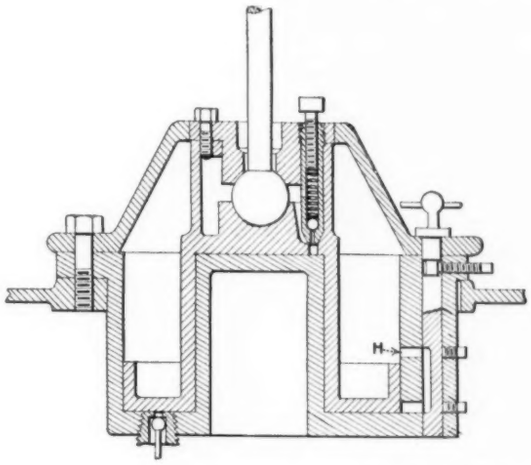


FIG. 97. INVERTED AND MORE ELABORATE THAN FIG. 96

time the pot is lifted, which would not be necessary if the regular vacuum chamber were made large enough to do the work. The amount of cushioning is regulated in a quick and effective way. On one side of the cushion chamber a hole is drilled vertically in an extension into which is fitted a straight plug having a groove milled on one side; this groove connects the two holes *H*, and by turning the plug the opening through the holes and, consequently, the cushioning can be closely regulated. This pot is about as nearly soundless as one can be made. There are no leathers required to counteract the shock of the descending plunger or pot, as on the other kinds. This is a great advantage, since the leathers wear out and have to be renewed.

The dashpots so far described are expensive and require skill in manufacturing, on account of the exact fits which must be made on the two concentric parts of the pot and the plunger. If one of the parts is out of true, the device cannot work satisfactorily. To avoid some of the difficult fits, there are dashpots made of one plug and vacuum chamber without the extra cushioning part. Fig. 98 illustrates one of this kind. The purpose of the arrangement is that the lifting of the plunger will create a vacuum sufficient under all conditions to close the steam valve, and that in coming down the plunger will compress the air that has entered the pot, forming an effective cushion, the air to be discharged when the plunger is near the bottom. To accomplish this result, the diameter of the plunger must be comparatively large, since full atmospheric pressure cannot become effective as in the two-chamber pots. Some manufacturers persist in using these single-plunger dashpots and obtain good results with them for steady

loads, but for varying loads they are not satisfactory since they have to be adjusted every time the load changes considerably. If the shifting valve *I*, in Fig. 98, and the air-inlet valve *K* are set for a heavy load, the plunger will stick near the bottom when the load gets light, and if adjusted for a light load, it will hammer as soon as a heavy load is thrown on. Compressing air in the lower part of the pot with a blow has quite a heating effect. This can be seen if oil is poured around the plunger; as soon as it gets to the bottom of the pot, it will

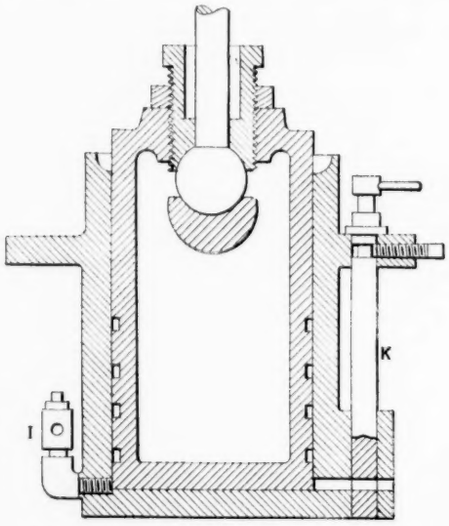


FIG. 98. SOMETIMES THE PLUNGER STICKS

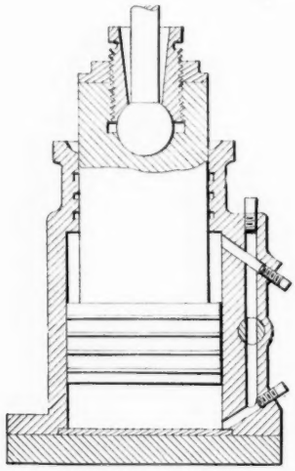


FIG. 99. NOTE THE AIR PASSAGES

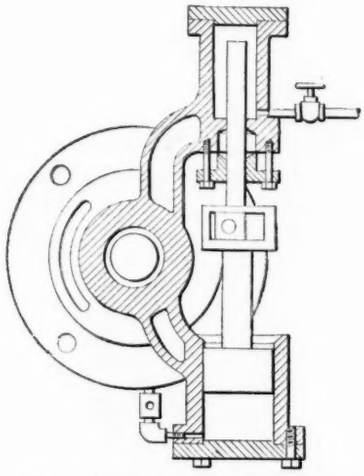


FIG. 100. A TOO-COMPLICATED DASHPOT

evaporate and be discharged in the form of a white vapor or smoke. Leather cannot be used in this pot to deaden the blow of the plunger, for it would soon be converted into charcoal.

A dashpot that made quite a sensation some years ago is shown in Fig. 99. It is provided with a differential plunger which in its upward movement compresses air above the larger part and forms a partial vacuum below. Air is forced through the holes drilled into an extension on the side of the pot, making a passage between the upper and the lower chambers, stopped by a taper plug. Most of the air will pass from the upper into the lower chamber in the upward motion, and on the down stroke will be forced back again, so that a continuous exchange of air takes place between the two chambers. On the down motion a partial vacuum will also be formed in the upper chamber and it is claimed this will have a retarding effect on the plunger. This pot is open to the same objections as the one with the single plunger and chamber—it is deficient on varying loads and needs frequent adjustment.

Perhaps the most trying conditions for dashpots are those that prevail when a direct-connected engine is run on the friction load with, say, 150-lb. pressure at the throttle and the brushes thrown off the commutator. Under these circumstances the steam valve will barely open, and the lift of the dashpot plunger is so small that it requires a high vacuum to force it down again after the valve gear has been tripped. Few dashpots will work under these conditions. It is unpleasant to see Corliss engines run on very light loads with full-pressure steam and the throttle wide open. It looks almost as if the valve gear were trying to pound itself to pieces. The steam pressure should be regulated to some extent according to the load, and every engineer who has any regard for his engine will attend to this. One of the requirements of a perfect-running valve gear is that the dashpots must always come down to the lowest position. For a varying load this is hard to attain without repeated adjustment, but there are times when the attendant cannot watch them, with the result that the valve gear gets noisy and troublesome. To overcome this, steam dashpots have been tried. The principle of such a pot is shown in Fig. 100. It consists of an upper steam cylinder and a cushion pot below, with the necessary piston for each. A small steam pipe with a stop valve is connected to the steam cylinder. The steam arm is attached to the block which slides in the slotted hole in the middle of the piston rod. The action is simple, and if everything is in working order it is positive. The valve gear pushes the steam piston up into the cylinder, and the pressure of the steam forces it down again, as soon as cutoff occurs, till the cushion piston touches the bottom. There can be no doubt about the effectiveness of this device, but one has to contend with steam

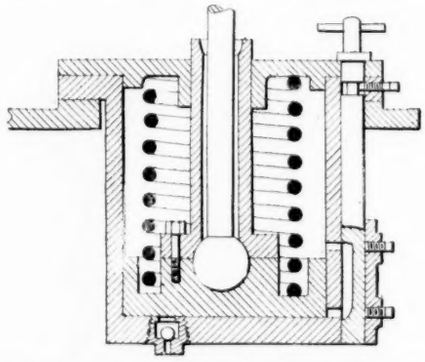


FIG. 101. SPRING-OPERATED DASHPOT

piping, stuffing-boxes, wear of steam piston, troublesome connection to the steam arm and also with varying steam pressures. Although in theory steam dashpots are good, in practice they have failed. They are hard on all the other parts of the valve gear.

Another pot is the spring dashpot, shown in Fig. 101. The weak point of this is that it relies on the action of the spiral spring to force the plunger down.

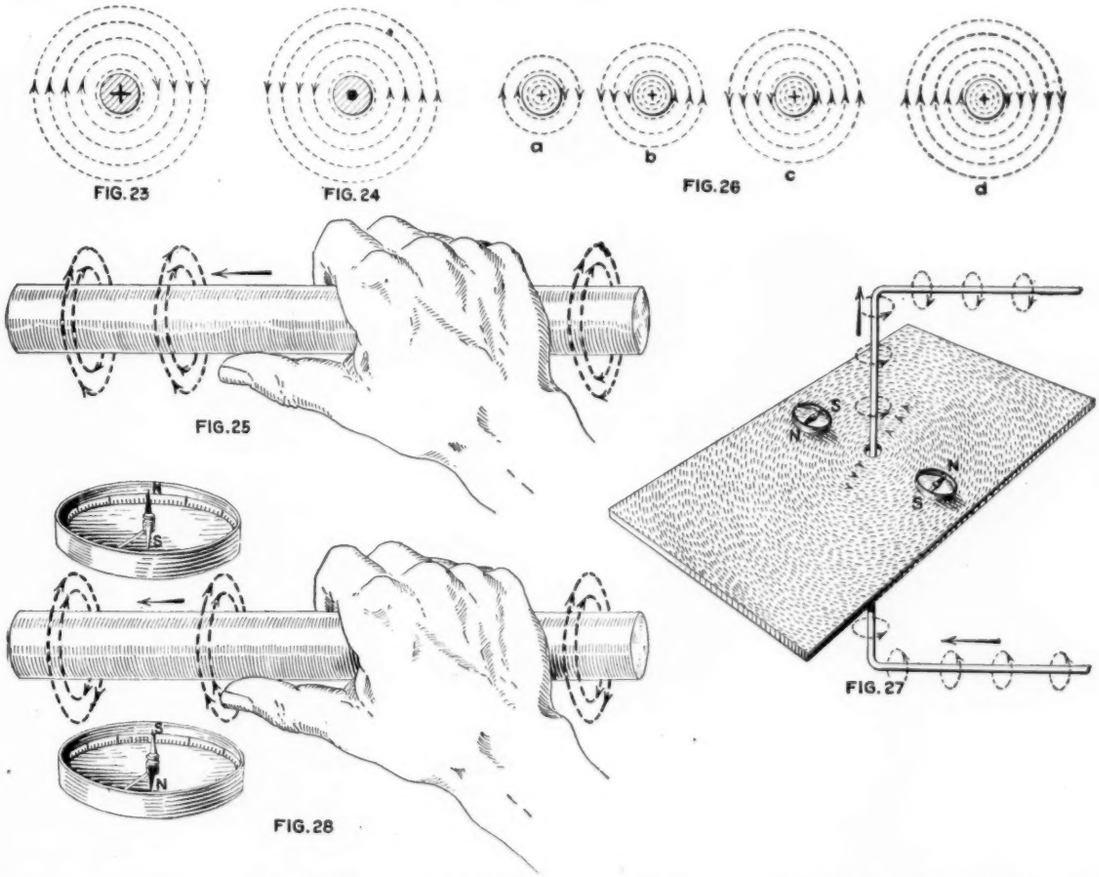
The Electrical Study Course—Elements of Magnetism—III

SYNOPSIS—The two preceding lessons treated of the properties of permanent magnets and the theory of magnetism. In this lesson the magnetic field set up about a conductor carrying an electric current is considered, and how the magnetic fields set up about the various turns of a coil of wire with an electric current flowing through it coalesce into one field, which encircles the entire group of conductors, giving to the coil the properties of a magnet.

As pointed out in the introductory article, there may be magnetism without electricity, but not electricity without magnetism, just as heat can be produced without light, but light cannot be produced without heat. What the relation of one is to the other is a scientific question that is not settled. But that has nothing to do with our study; suffice it to keep the fact in mind that when an electric current flows through a wire, it sets up a magnetic field about it. This is a very important feature in the whole study of electricity and magnetism, as will be seen as our studies progress.

The directions of the lines of force about a conductor with a current of electricity flowing through it will depend upon the direction of the current. The direction of the current and the corresponding direction of the magnetic flux about a conductor is indicated in Figs. 23 and 24. In these figures the full-line circle represents the cross-section of the conductor, the dotted circle and arrowheads the magnetism and its direction, and the crosses and dots in the center of the circles the direction of the current. It is important that the two latter conventionals be firmly fixed in the mind, since they are frequently used to represent the direction of current flowing in a conductor. In Fig. 23 the cross represents current flowing away from the reader. It will be seen that the lines of force are whirling in a clockwise direction. The dot in the center of the circle, Fig. 24, indicates current flowing up through the plane of the paper. This is just opposite to that in Fig. 23, and as will be observed, the direction of the magnetic field about the conductor has reversed, or is now in a counter-clockwise direction.

These things are so simple that it is hard to remember just what each represents; therefore a rule will not be out of place. Referring to the direction of the current in the conductor, the cross and dot in the center of the circle may be considered to represent an arrow moving in the direction of the current, the cross representing the tail of the arrow and the dot the point. Consequently, if we wish to know which direction of current the cross represents, we may reason like this: The cross



FIGS. 23 TO 28. MAGNETIC FIELD SET UP BY AN ELECTRIC CURRENT WHEN FLOWING THROUGH A WIRE

represents the tail of the arrow, therefore the arrow must be pointing away from the observer for this part to be seen. Hence, the cross represents current flowing away from the reader. Likewise for the dot; it represents the point of the arrow. The arrow must be pointing toward the observer for the point to be seen, consequently, the direction of the current which it represents.

The next thing to remember is the direction or the lines of force about the conductor. A simple rule for this is to grasp the conductor in the right hand with the thumb pointing in the direction of the current, as indicated in Fig. 25; the fingers will then point around the conductor in the direction of the lines of force.

The field about a wire carrying an electric current does not take the form of a spiral, but a circle, as shown in the figures. These circles seem to emanate from the

This fact may be used to determine the direction of an electric current in a conductor. In Fig. 28 is represented a wire carrying a current in the direction of the arrow; the magnetic field is shown by the dotted circles and arrowheads. If a compass is placed on top of the conductor, it will point in the direction of the magnetic field above the wire, likewise if placed underneath; namely, as indicated in the figure. After the direction of the magnetic field has been determined by the compass, if the wire is grasped in the right hand with the fingers pointing around the conductor in the direction that the compass points, the thumb, when pointing along the conductor, will indicate the direction of the current, as illustrated in the figure.

In Fig. 29 are represented two parallel conductors having an electric current flowing in the same direction

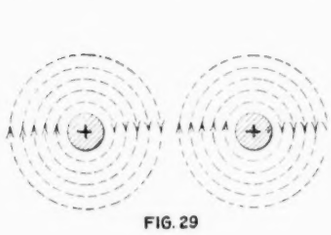


FIG. 29

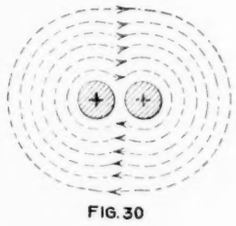


FIG. 30

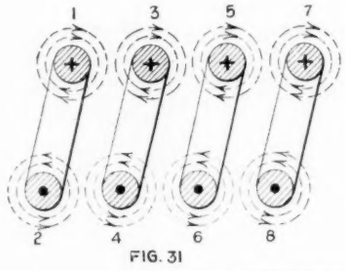


FIG. 31

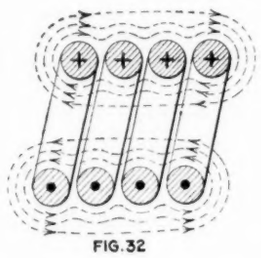


FIG. 32

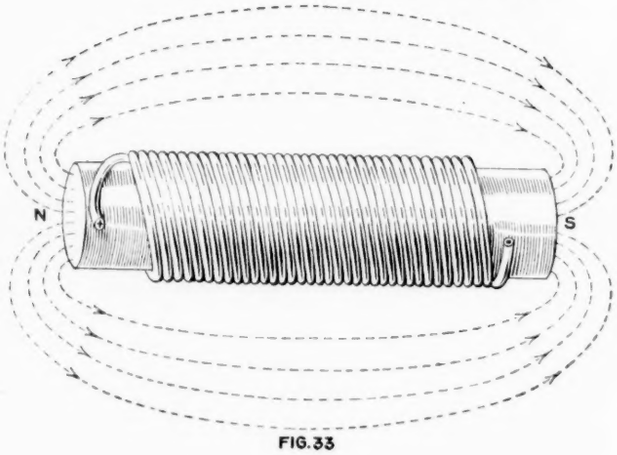


FIG. 33

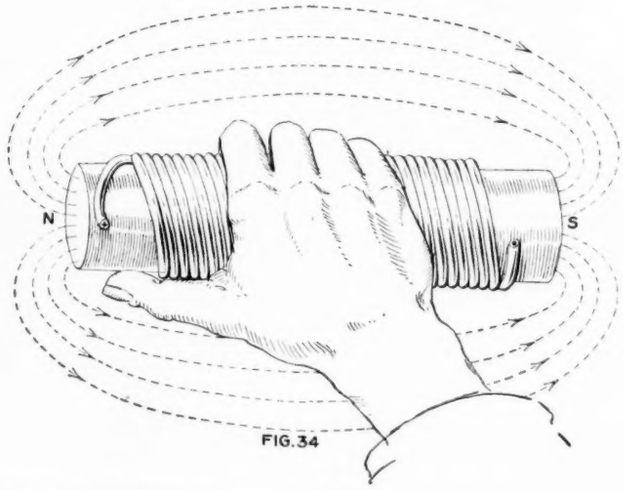


FIG. 34

FIGS. 29 TO 34. ILLUSTRATES THE THEORY OF THE ELECTROMAGNET

center of the conductor and have an increasing diameter as the current increases. This is illustrated in Fig. 26 *a*, *b*, *c* and *d*. At *a* is represented the effect that would be obtained from a small current flowing in the conductor; at *b*, *c* and *d*, the successive development of the magnetic field as the current flowing through the wire increases.

There are several ways of determining that a magnetic field is set up about a conductor carrying an electric current. If a wire is placed through a hole in a piece of glass or cardboard, as shown in Fig. 27, and an electric current is caused to flow through the wire, then if iron filings are sprinkled upon the glass or cardboard, they will be arranged in broken circles, as indicated in the figure. To get the best effect it will probably be necessary to tap the edge of the surface. Placing a compass in various positions as shown, it will always point in a definite direction around the conductor. It will be observed that the compass points in an opposite direction on opposite sides of the wire.

in each and supposed to be far enough apart so that the magnetic field of one will not have any influence on that of the other. The direction of the magnetic field between the two conductors will be seen to be in an upward direction on one and downward on the other. If the two conductors are brought near together, the two fields between them will oppose each other and since the field strength of both is the same, no lines of force will pass between the wires, for be it remembered that equal opposing forces in magnetism neutralize each other just as equal opposing mechanical forces neutralize each other, but this does not destroy the magnetic field in this case. The result of bringing the two conductors close together is shown in Fig. 30. It will be seen that the whirls about one wire have combined with those of the other, and now the lines circle the two conductors instead of one and this field has the same relative direction as that in Fig. 29.

If a number of conductors are placed alongside of one another with an electric current flowing in the same

direction in them, all their magnetic fields will combine and form a field that will encircle the group. This is the effect obtained in a coil of wire connected to a source of electricity. In Fig. 31 is shown the cross-section of a coil of four turns; the direction of the current through the coil is indicated by the crosses and dots. That is, it flows in at 1 and out at 2, in at 3 and out at 4, etc. The turns are supposed to be separated far enough so that the flux of one will not affect that of the other. From an examination of the figures it will be seen that the direction of the lines of force on the inside of the coil all point in the same direction, likewise on the outside. Consequently if the turns are placed together as in Fig. 32, the magnetic fields about the different conductors will coalesce into one and surround the whole group of conductors, as shown. That is, we would have a magnetic field emanating at one end of the coil and entering at the other, just as we did with the permanent and natural magnet. In the case of the coil, however, it is called a solenoid, but it has all the properties of a permanent magnet. It will attract pieces of iron, and if suspended by a string so that the axis of the magnetic field is in a horizontal position, it will point north and south just the same as a permanent magnet.

If the coil is supplied with a soft-iron core, as in Fig. 33, the combination is called an electromagnet. Although this device possesses the properties of a permanent magnet, it will remain magnetized only as long as current is flowing in the coil, and is therefore a temporary magnet. All electromagnets are temporary magnets.

A convenient rule for determining the polarity of an electromagnet when the direction of the current in the coil is known, is shown in Fig. 34. This is the rule for the direction of the flux about a conductor backward. If the coil is grasped in the right hand, as shown in the figure, with the fingers pointing in the direction that the current is flowing in around the coil, the thumb will always point toward the north pole of the electromagnet. This is a convenient rule, often used, and an easy one to remember.

Some Results of Recent Work in Surface Combustion

By Henry L. Read*

SYNOPSIS—The jet of air and gas is put far enough away from a refractory bed of alundum to allow sufficient reduction in velocity of air and gas to make combustion complete in the bed. The author finds that surface combustion fires roar, however good the adjustment of mixture.

Two articles in *Power* by L. J. Bradford and C. D. Corwin on "Some Recent Experiments in Surface Combustion"[1] summarized briefly some of the older ideas on this subject and gave the results of a preliminary investigation in steam generation carried out by the authors. As much work has lately been done along different structural lines, an outline of some of the more recent results are of interest.

The explanation now commonly accepted of what happens in surface combustion was originally given by Dr. C. E. Lucke. He states that the process is a simple burning of an explosive mixture of gas and air due to its being brought up to its ignition temperature. He discards all theories of catalytic action by hot surfaces and considers the acceleration of the combustion which apparently results from the presence of the hot surfaces as due more to the heating of the mixture. The greatly accelerated action is the result of the high velocity of flame propagation of explosive mixtures, which velocity is greatly increased by the high temperatures of the refractory bed. Looked at in another way, surface combustion is a continuous localized burning of an explosive gaseous mixture. This localization is fixed at the point where the flow velocity of the mixture equals the velocity of flame propagation.

The last sentence gives the basis on which new burners are constructed. It is evident that there are three possible conditions in connection with the burning of explosive gaseous mixtures: (1) When the velocity of the jet is greater than the velocity of flame propagation; (2) when the velocities are equal; and (3) when the velocity of the jet is less than that of the flame propagation. In the first case, obviously the jet will push the flame away from the burner orifice, causing the familiar "blowing off" effect seen in blast-gas burners when the air pressure is too great. In the second, the flame will stay fixed in some position, as it does, for example, at the outlet of the mixing tube of an ordinary bunsen burner. In the last case, the flame will travel back to some point depending on the construction of the burner, in a manner similar to the "pop back" that occurs in a bunsen burner when the mixture in the tube becomes explosive.

With surface combustion we are dealing with gas and air in an explosive mixture, and more especially with the very explosive mixtures of gas and air in the theoretically perfect proportions for complete combustion without any excess air. This mixture is made thoroughly homogeneous, and no secondary air is required for complete combustion. Because of its explosive character, provision must be made to preclude harmful results from backfiring. Backfire is prevented normally by making the velocity of the jet issuing from the burner orifice greater than the speed of backfiring, or flame propagation. But if a jet is then traveling too fast to burn at the orifice, it must be slowed down to permit combustion to take place somewhere else, and this will be where the velocities of the jet and the flame propagation are equal.

After much experimentation it was found that if the jet from the burner, moving at a suitable velocity, was directed against a bed of loose lumps of refractory material such as alundum, the velocity would be properly

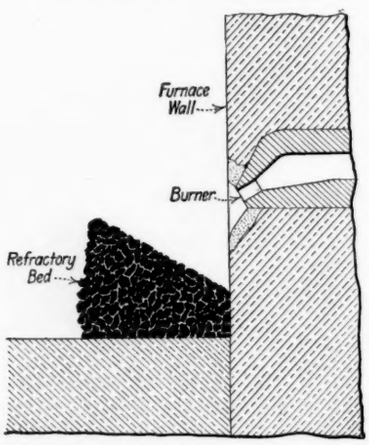
*Engineer of tests, the Surface Combustion Co., Long Island City, N. Y.

[1] "Power," Vol. 42, pp. 787 and 855.

reduced by this bed, so that combustion would take place in or at the surface of the bed; the illustration shows the arrangement.

By putting the nozzle at the outlet of the burner, the velocity of the jet is increased so that the mixture pressure may be reduced below $^2/_{10}$ in. of water without a backfire. In practice a bypass is placed around the main air valve so that the pressure can never drop below $\frac{1}{10}$ in. unless the air supply fails. Should this happen and a backfire occur, the design is such that no damage can be done.

It might be thought that the jet shooting through space for a short distance would entrain considerable of the surrounding atmosphere, which consists only of nitrogen, water vapor and carbon dioxide, and that consequently the flame temperature would be much reduced. That this is not the case is shown by the fact that the temperature in the hot part of the bed is very close to the theoretical flame temperature of the gas used. This may be explained by the fact that a cylinder of flame forms at a short distance from the burner orifice, extending down into the refractory bed, preventing the hot furnace gases from mixing with the jet by the formation of a flame surface between the two. The sides of the jet really burn away as it attains ignition temperature and this prevents entrainment. This flame occurs here because the high temperature of the furnace gases ignites the mixture. The effect is to cause a small amount of the mixture to burn before it reaches the bed.



REFRACTORY MATERIAL AT DISTANCE FROM NOZZLE OF BURNER

Bradford and Corwin reported several points of interest, but one that was rather puzzling was the statement that the fire, while noisy when first lighted, gradually became more and more quiet until, when proper conditions were established, the sound practically ceased. They explain that this is due to the gradual disappearance of the flame, saying that their boiler tube acted as a resonator. It has been the experience of the writer that invariably there is a distinct roar from surface combustion fires, even at the best adjustment. Another point worthy of note is that with excellent adjustment there is always a distinct appearance of flame in the furnace, especially at the bed. This may be due to the gases being so highly heated as to be visible, to minute particles of dust, to combustion not being complete even at the very high temperature of the bed (about 3500 deg. F.) due to dissociation of the end products, or to all three. But whatever the cause, it is certain that perfect combustion can be and is obtained in operation, for on numerous occasions adjustments have been made so that flue-gas samples taken from inside the furnace with a nichrome sampling tube have analyzed O_2 zero per cent. and CO zero per cent. in the Orsat. With the type of mixing device now used, which includes a specially formed and proportioned venturi tube, the Orsat apparatus never detects both O_2 and CO in the same sample, although the apparatus may be adjusted to give one or the other in the combustion products. A fair flue-gas analysis is 15.1 per cent. CO_2, 0.2 per cent. O_2 and 0.0 per cent. CO.

The peculiar effect noted by Bradford and Corwin, that an explosion in the tube caused the nozzle and firebrick bed to be driven forward, was probably due to the rise in pressure in the tube accompanying the explosive wave causing a momentary check in the flow of mixture in its piping Consequently the mixture back of the nozzle also exploded and, being confined, moved the nozzle and bed, since the pressure in the tube was quickly reduced to atmospheric. By lessening the distance between the fireclay nozzle and a 3-in. cap, they reduced the mixing space and obtained probably a less homogeneous and consequently a less explosive mixture. This may be the explanation of why they were able to light the fire so much more easily when this distance was small. This view is strengthened by the statement made by these authors that practically no sound accompanied the combustion, since this would indicate that they did not have the perfect explosive mixture. Another thing that casts doubt on their mixture is that they were able to use firebrick in their refractory bed. The writer's experience has been that firebrick can be readily fused in a properly adjusted surface-combustion fire.

Some results on comparative tests between surface-combustion furnaces and similar standard blast-burner furnaces may be of interest. In lead melting, the surface-combustion furnace showed a saving of 33 per cent. over an ordinary furnace. On other lead-melting work the saving in gas over a standard furnace was 44 per cent. A comparative test between two annealing furnaces showed a saving of 28 per cent. for surface combustion. In addition to the savings that are shown by practical results is the fact that, owing to the simplicity of the controlling devices and the radiant heat, heating that previously could not be done satisfactorily by gas at all can now be effected properly.

The high radiating power of the bed and the absence of excess air in the furnace make the process an ideal one for burning any kind of gas, and especially producer and natural gas under boilers. The water-tube type of boiler is probably the one best adapted to it. By placing the tubes close to the bed advantage is taken of the high temperature and direct radiation without the slightest danger of causing incomplete combustion. Present experiments indicate that the only limit to the amount of gas that may be burned in a given space is the ability of the refractory materials in the furnace to withstand the temperature.

Bursting Strength of 4-In. Malleable-Iron Threaded Tees, black and galvanized, designed for 150 lb. working pressure, show an average of 2,900 lb. for the black and 2,833 for the galvanized fittings:

Test	Black or Galvanized	Ultimate Test Pressure, Lb.	Weight of Fitting, Lb.	Average
1	Black	28,000	10.06	2,900
2	Black	31,000	10.12	
3	Black	28,000	10.19	
4	Galvanized	27,000	10.62	2,833
5	Galvanized	30,000	10.50	
6	Galvanized	28,000	10.75	

Standard cast iron, 1,850 app.

Comparison shows that the malleable fittings of the same weight and general design are 50 per cent. stronger than cast iron not annealed or made malleable.

Editorials

Coal Conservation in New England

To save is not to be efficient—not necessarily. But to be most efficient is to be most saving. Platitudes and epigrams may inspire a few noble souls to make our resources go as far as human ingenuity can make them go; but for the run-of-mine individual it is the frenzy he works himself to when vociferating on the iniquities of high prices that makes him strive to be efficient.

At present no better illustration of the truth of this is to be had than among New England coal consumers. Until recently nearly all the coal used in New England came from the West Virginia fields over rail to Hampton Roads and thence by boat to Providence, Boston and Portland. Previous to the war it was sold at $2.70 to $2.85 per ton f.o.b. Hampton Roads and $4.20 to $4.75 on the cars at Boston. Today the same coal is costing upward of $8 per ton on the cars at Boston, while central Pennsylvania steam coal is being sold on contract for $3.25 to $3.50 f.o.b. the mines, and $6 to $7 on the cars at Boston. Many persons interested in as many ways have expounded to New Englanders and others the virtues of boiler-room economy. Books have been written, tables compiled and no one knows how many lantern slides at fifty cents apiece have been used in this boiler-efficiency propaganda. Yet lo! The simple expedient of increasing the price of coal a hundred per cent. gets immediate action and on a scale that years of lecturing would not have accomplished.

There are tons of perfectly good water at 100 to 200 degrees going back to the boilers in New England plants today that went to the meager rivers heretofore. The ash, if analyzed, would show a minimum of combustible. There is real attention paid to plant records these days in many plants where records were scoffed at previously. After all, a stab at the pocketbook is stimulating.

The River Station

There is described in this issue the outstanding engineering features of the most modern power-plant design as represented by the River Station of the Buffalo General Electric Co. The boiler pressure of two hundred and seventy-five pounds with two hundred and seventy-five degrees superheat, the highest in use in American stationary practice though plants to use higher pressures are building, is indicative that the much-talked-of higher boiler pressures are already on the way. It is interesting to know that when Henry G. Stott, consulting engineer for the owners, was planning this station, a boiler pressure of six hundred pounds was seriously considered. The use of two hundred and seventy-five pounds with two hundred and seventy-five degrees superheat is therefore a compromise and will likely be regarded by most engineers as a happy and conservative one.

With regard to the future of higher pressures and superheat and their influence on design and operation, the symposium at the end of the article referred to, to which leading authorities have contributed, is the broadest expression on the subject yet published and clearly shows that those who greatly influence the trend of power-plant practice look with favor upon this development of apparatus and methods to the end that such pressures may be used and the theoretical economy, or rather as much of it as possible, be made actual.

Granting that because of the diversion of hydro-electric power from the American to Canadian use as compelled by the Ottawa Government, a steam plant became necessary to meet demands, it is noteworthy that a turbine steam station has been built in the very shadow of Niagara and that even there, where no dam was necessary, a modern steam-turbine station can successfully compete with water power when the latter's load factor is below fifty per cent. This is indeed a tribute to turbine designers and to plant operators—to the latter because of the constant vigilance and skill required to get and to maintain the utmost out of the equipment.

There are too many features about the station to allow, in the space available, editorial comment of each. We do wish to emphasize the value of the table of ratios, proportions, capacities, etc., that the author has included in the article. This is new in descriptions of power plants, although the author gave a similar table in an article treating of the thirty-thousand kilowatt turbines of the Seventy-Fourth Street Station, New York City, in *Power* for April 20, 1915. Notwithstanding that such tables relate to a particular plant, when that plant represents excellent practice, local conditions considered, the data should be found of much use to designers and operators, and for use in steam-engineering courses in schools and universities.

Those not familiar with the Niagara Falls power situation will desire more information than could properly be set forth in the article, and for this reason a brief review will be given here:

The United States has a treaty with the Canadians according to which the former may divert twenty thousand second-feet and the latter thirty-six thousand second-feet of water from the Falls for power purposes. Many of the industries on the American side have been supplied with power to the amount of about one hundred and fifty thousand horsepower out of a total of three hundred and sixty-nine thousand horsepower from the Canadian side. The Province of Ontario is rich in water power, having roughly five million horsepower available for development. The Hydro-Electric Commission of that province has lately moved the Ottawa Government to compel the Canadian Niagara Falls Power Co. to supply the former with as much power as it demands, to the curtailment of power which the latter has been exporting to the American side. Of course, the industries at the Falls, nearly all very large consumers of power, were badly hit, and labor suffered because hundreds of men were thrown out of work by the curtailment of power.

All of the twenty thousand second-feet allowed by the treaty is not being taken from the American side and appeals to Secretary of War Baker to make the full amount immediately available failed. He referred the matter to Congress rather than assume the responsibility himself.

During early January a resolution came into the Senate from the House, passed and was referred to a conference committee for slight revision. Here is the resolution:

"That the Secretary of War be and he is hereby authorized to issue permits, revocable at will, for the diversion of water in the United States from the Niagara River above the falls for the creation of power to individuals, companies or corporations which are now actually producing power from the waters of said river in additional quantities, which, with present diversions, shall in no case exceed the capacity of the generating machinery of the permittee and tenant companies now installed and ready for operation, nor an amount sufficient to enable the permittee to supply the now existing hydro-electric demands of the individuals, companies or corporations which said permittee and tenant companies are now supplying, but not in excess of the capacity of power-using appliances of said consumers now installed and ready for operation: Provided, that in no event shall the total quantity of water diverted from said river above the falls for power purposes exceed in the aggregate a daily diversion at the rate of 20,000 cubic feet per second: And provided further, that this resolution shall remain in force until the first day of July, 1917, and no longer, at the expiration of which time all permits granted hereunder shall terminate, unless sooner revoked; and nothing herein contained shall be held to confirm, establish or confer in or upon any such permittee any right in or to the water which he is now diverting or which he may be authorized to divert hereunder."

That the power available on the American side even with the full quantity allowed by the treaty taken will not be sufficient for the community's needs is evidenced by the erection of the River Station. It would appear that the Canadians had visions of the large industries at Niagara Falls moving across the river. If so their hopes have been blasted, for some of these even now have well on the way new works contiguous to the River Station which will furnish them with power.

A College Course on the Human Side of Engineering

Hitherto there has been more interest taken in the development of engines than of engineers. The realization is growing that the morals, the mental and physical condition, the proficiency of the human element in industry, have a greater bearing upon ultimate efficiency than any tolerable difference in the condition of the tools and apparatus that he handles. Big things are being done toward humanizing industry, toward imbuing each worker with the spirit of coöperation and combined effectiveness. Under the leadership and inspiration of the Young Men's Christian Association, professors and undergraduates of technical schools and colleges have been undertaking the education in English, mathematics, mechanical drawing, etc., of workingmen, and have gained in breadth of view and increased value as managers of men more than they gave.

There is now suggested a college course on the human side of engineering. It is, as we understand it, now in the formative stage and suggestions are solicited. Copies for this purpose may be obtained from Fred H. Rindge, Jr., Secretary, Industrial Service Movement, One Hundred and Twenty-four East Twenty-eighth Street, New York.

An Example of Co-operation

According to a recent newspaper account, Senator Hoke Smith of Georgia offers the General Naval Board cheap electric power and pig iron for the manufacture of armor plate at the proposed Federal plant. Senator Smith's tender is to the effect that if the eleven million dollar armor-plate plant is erected at Rome, Ga., electric energy will be furnished to this plant at four and one-half mills a kilowatt.

There are vast water-power resources in the northern part of the state, which permit of the generation of electricity in large quantities. The use of energy by the proposed armor-plate plant would indeed be an incentive to the hydro-electric system to sell such of its output as would be required, at a very low rate, on account of the increased load factor that would result from the heavy demand for power, if for no other reason.

Another inducement offered is that of providing cheap pig iron from the mines that are within twenty miles of the proposed site of the armor-plate plant. The railroads have entered into an agreement with the mine operators making it possible to supply iron at a price as low as that asked by any other mines or railroads in the United States. It is not to be assumed that the rates for electrical energy, pig iron or freight will be such that there will be a loss to the hydro-electric plants, mines or railroads, but the getting together and making a rate that is attractive shows good business sense on the part of each.

Naturally, the power plants are in a position to supply more energy than they are now doing; the machinery is operating, and an additional load could undoubtedly be taken care of, which even at a small profit would be of advantage. The mines have their operating equipment, and a home market in addition to their present sales should permit of mining on a larger scale. The railroads have their tracks and rolling stock, and more freight could be handled to advantage, at a figure attractive to the consumer with very little additional expenditure on the part of the carrier.

Back of all this there is evidently the feeling of local pride in building up home industries. Every community experiences that impulse, and the same is true of the larger interests.

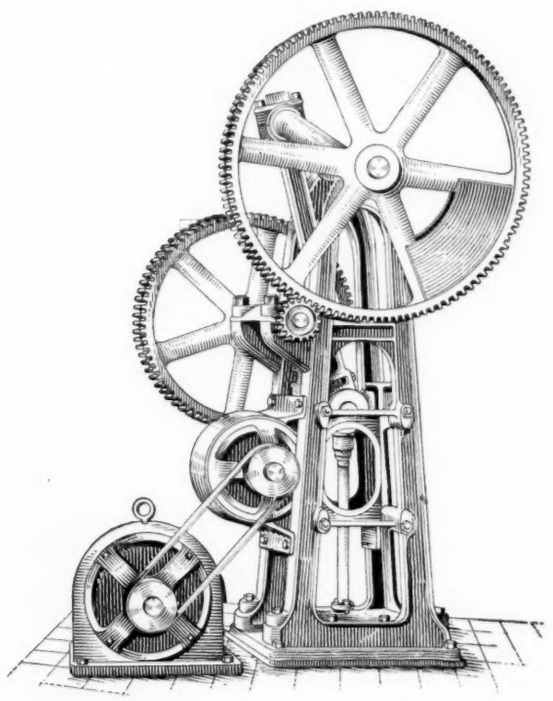
Once in a while there is evidence that a company, either commercial or public-service, has a disposition to carry on business with a motive other than that of extracting the last cent of revenue from those that must do business with it.

If this principle could be carried out in the general business world, conditions would be materially changed and satisfied customers would be more in evidence. The example of the electric, mine and railroad companies of Georgia in the fostering of a new industry for that state might well be followed in the business relations of manufacturers with the power plant.

Correspondence

Emergency Motor Service for Ice Plant

In a ten-ton ice plant driven by coal-oil engines, in which a 10-kw. 220-volt direct-current generator furnishes current for the lights and a few motors, everything went well with the electrical equipment until the deep-well pump motor bearings went dry and were cut to pieces, allowing the armature to get against the field poles,



TEMPORARY MOTOR BELTED TO PUMP THROUGH A SHAFT RUNNING IN THE PUMP MOTOR BEARINGS

thus cutting off the bands and damaging a few of the coils that came out of the slots. With the pump stopped, the entire plant had to be shut down, as there was no cooling water for the engines. The armature and bearings were sent twenty miles to the nearest electrical repair shop, where the bearings were rebabbitted, the coils patched, new bands put on and the commutator turned.

As a result of improper setting of the brushes, the commutator had been so deeply grooved that it could not be turned the full width of its face without danger of cutting off the risers. While the attention of the owner was called to this condition, no effort was made to obtain a new commutator or armature. The old commutator lasted about three months, when one of the thin end of the bars bent over onto an adjacent bar, short-circuiting two coils. Before the motor was stopped, six coils were destroyed. The armature was taken to the repair shop the second time, and the six damaged coils were cut out. There were 97 coils in the armature, with a wave connection which gave two parallel paths. The current taken by the motor after the coils were cut out was but two amperes more than it was before. The winding did not become dangerously hot.

In order to keep the brushes off the thin ends of the commutator bars, they were cut away on the outside edge until but half of the original bearing surface was left. It is to be expected that there was a little sparking and that the brushes wore away rapidly. After three weeks' running another segment was dragged over onto the next one, burning the armature winding beyond repair. Once more it was taken to the repair shop, where its shaft was measured for a temporary shaft to fit the motor bearings and carry a pulley on the outside of the commutator bearing. With this new shaft running in the motor bearings, another motor of the same rating, but much larger, was set on the floor beside the pump and belted to the pulley on the new shaft, as shown in the figure. The same starting box and wiring were used. This makeshift was in operation for seven weeks without any trouble and kept the ice plant running every day until the armature was installed.

R. L. HERVEY.

Washington, D. C.

Trouble from Hard Water in Boilers

In a certain power plant considerable trouble has resulted from the hard water used in boilers. This water, having both permanent and temporary hardness, is treated by the lime-soda process in a settling-tank system and an excelsior filter. The trouble is that if enough chemicals are not used the boilers form considerable scale, but if sufficient chemicals are used to prevent scale the steam carries considerable lime into the line, and this in turn limes up the turbine blades.

The plant operatives have read and experimented a lot, but up to the present have not obtained satisfactory results. There must be some way of overcoming this difficulty, and possibly some reader of *Power* who has done so will give us the benefit of his experience.

New York City. GEORGE SMITH.

Do Blowers Cause Clinkers?

Owing to the increased demand for steam, it became necessary to provide a means of intensifying the draft in the furnace. This was accomplished by the installation of a turbine-driven under-grate blower, but shortly the firemen began to complain of a hard clinker formation and blamed the new blower for it. Previously, the draft was induced by fans in the stack and the air entered the ashpit at boiler-room temperature.

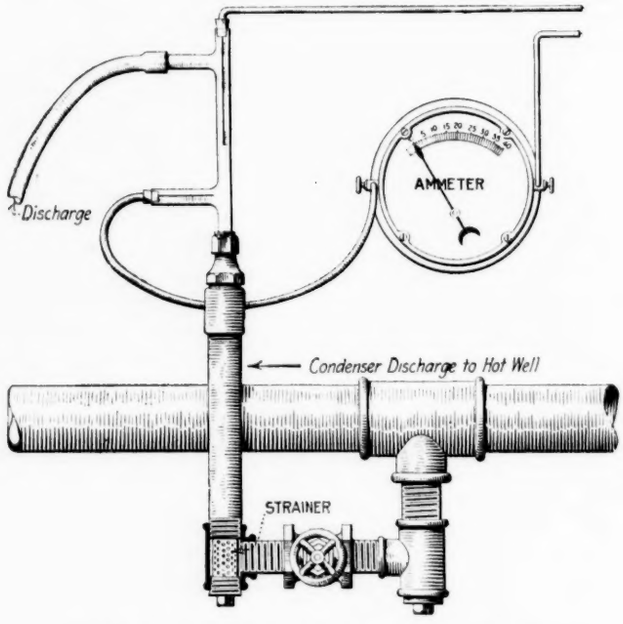
Clinker is due, we are told, to melted ash which is the result of an exceedingly hot fuel bed. As there was no trouble from clinker before the under-grate blower was installed and as there was difficulty from that source afterwards, one conclusion is that the greater draft is the cause of a considerably increased fire temperature melting the ash and producing clinkers. It is a question, however, whether the increased draft alone would cause

the clinkers. The air entering the ashpit and fuel bed under the old system was at practically boiler-room temperature, and this tended to keep the fuel-bed temperature down, but with the new blower the air is mixed with the exhaust steam from the blower turbine. The new blower produces more draft, but the exhaust steam is mingled with the air which is forced through the fuel bed. This may or may not have something to do with the increased clinker formation. I should like to have a discussion of this subject by readers.

Washington, D. C. H. G. GIBSON.

A Positive Salinity Indicator

I, as well as other engineers, have had more or less trouble on account of salt water getting into the boilers owing to leaky condenser tubes, and they are not always discovered until the water is pretty bad particularly when the load is heavy. Of course, in a great many plants chemical tests are made at regular intervals to determine the condition of the condensate at that particular moment, but for many reasons this method is not reliable. In the issue of Oct. 24, page 602, a feed-water testing outfit was illustrated and described, but the equipment is open to some objection for the batteries are not of sufficient strength to close the circuit and also give a sufficient meter-reading range, and the user is compelled to draw samples continually. The apparatus I have is positive and gives entire satisfaction, and it has been the means of saving considerable time and expense. We have 440-volt a.-c. current available, so a transformer was made by our chief electrician, to give a maximum range of 600 volts. A meter was purchased at small expense and connected up with the arrangement of piping, etc., as shown in the illustration. The principle of operation is the same as with the one previously described, the continuous operation being the chief feature. With this rig the condition of the water is constantly under observation as the circulation through the glass tube permits of a continuous change of water. When first placed in use, different amounts of sea water were put into the condenser discharge and chemical tests were made and meter readings taken simultaneously, and the meter was checked accordingly, so that no other readings or computations were necessary. F. G. SEAVER.



DEVICE FOR INDICATING SALT IN WATER

Emeryville, Calif.

Obtaining Several Voltages for Battery Charging

Having a varying number of storage cells of different capacities to charge, it became highly desirable to obtain voltages as near as possible to the actual requirements in order to avoid too much energy loss in the charging resistance.

An unused 5-kw. 4-pole 110-volt direct-current exciter was set up in the shop and driven from the line-shaft at three different speeds by means of cone pulleys, each speed suiting the voltage required. By properly connecting three double-pole double-throw switches *A*, *B* and *C* in the field circuit, as shown in the figure, the proper grouping of the field coils was easily obtained, for the voltage required. By this means the field was always operated at the same strength, and the voltage therefore became proportional to the speed. It was found impractical to obtain the desired voltages by decreasing the field strength on account of unstable operation and sparking at the commutator.

For full voltage (110 volts) the field coils are connected in series and the machine is driven at full speed; for half-voltage (55 volts) the coils are in series-multiple and the machine is driven at half speed; while for one-quarter voltage (27.5 volts) the coils are all in parallel and the machine is driven at one-quarter speed. In order to take care of the larger field current at the lower speeds, an extra rheostat *ER*, which happened to be on hand, was arranged to be cut in parallel with the regular rheostat *RR* by means of a single-pole single-throw switch *S*. The machine operated better on the lower voltages and speeds

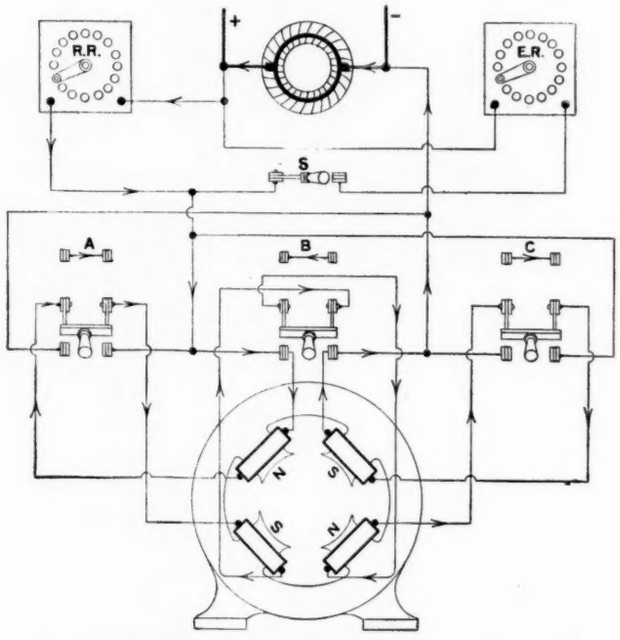


DIAGRAM OF CONNECTIONS FOR REGROUPING FIELD COILS FOR DIFFERENT GENERATOR SPEEDS

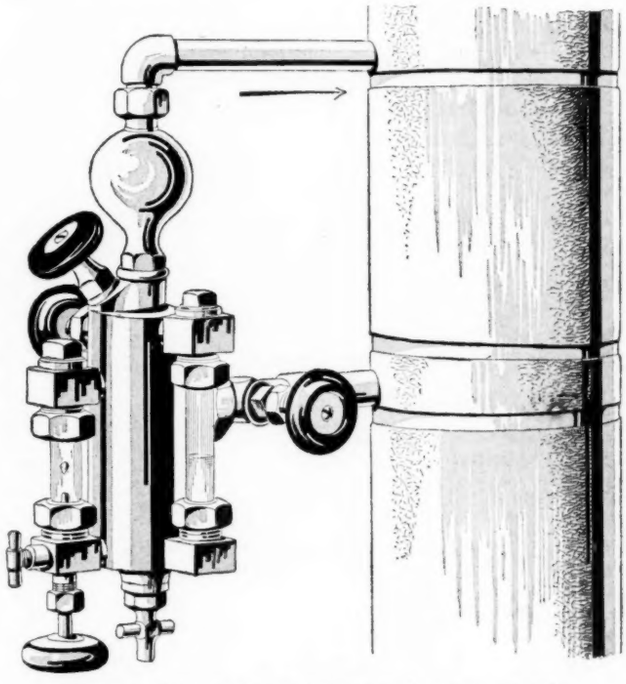
than at full voltage and speed on account of much better commutation.

Tracing out the circuits, it will be seen that with switches *A*, *B* and *C* closed in the up position, all coils are in series for 110 volts, as indicated by the arrowheads. With *B* down and *A* and *C* up, the coils are in series-multiple for 55 volts, while with all three down the coils are in parallel for 27.5 volts. For the last-named voltage the extra rheostat *ER* is cut in by switch *S*. Some time later, use will be made of the recently developed variable-speed alternating-current brush-shift motor for driving the generator, and then the cone can be dispensed with. In grouping the coils and switches, care should be taken to get all connections correct in order to retain all poles of the proper polarity in the various combinations and also to be sure to select the proper speeds for the voltages required.

Patchogue, N. Y. HENRY MULFORD.

Lubricator Connections

Many and varied are the opinions regarding the proper way of connecting up lubricators. The method shown in the illustration gives results so gratifying that I am passing it along. As the actuating force is the head or hydrostatic pressure available in the condensing chamber and the vertical pipe above, it is reasonable that the more constant is this pressure the more regular will be the operation of the lubricator. Lubricators are usually connected up with a vertical pipe extending some feet above the top, and the column of water may vary in height the entire length of the pipe. The higher this column of water the nearer closed will the feed valve have to be for any given flow of oil, and the nearer the feed valve is closed the more difficult it is to make fine adjustments in feed. Therefore, instead of a long vertical pipe above the condensing chamber, I use a street ell right at the top and go directly into the steam pipe. This gives a small hydrostatic pressure, and there can be but little variation, and this permits a comparatively large opening of the feed valve. The regulation is much easier, consequently it is easier to "save the drops." J. M. ROW.

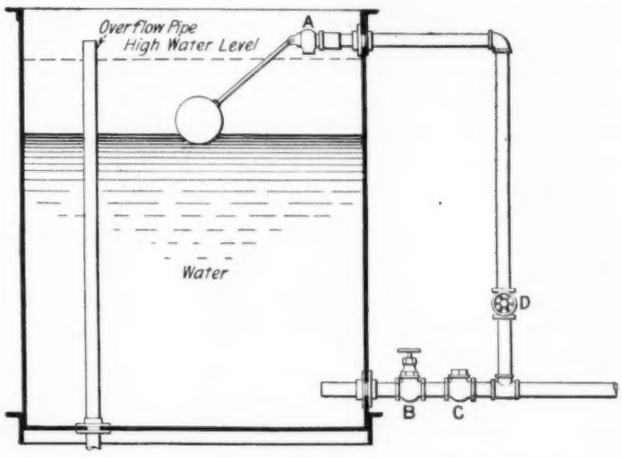


LUBRICATOR CLOSE-CONNECTED AT THE TOP

Wichita, Kan.

A Two-Pressure Water-Supply

An elevated water tank gave a pressure of 40 lb. at the ground floor. This pressure was all right for night service, but 60 lb. was required during the daytime. The tank was supplied by a duplex steam pump, and the distributing connections or branches for the institution were taken from the pump discharge to the tank. To secure a higher pressure, the connections shown in the illustration were made. When the water reaches the high level in the tank, the ball-cock *A* closes and a pressure-regulating valve on the steam supply to the pump controls the pressure, keeping it at 60 lb. on the line. At 6 p.m. the pump is shut down and the water required at basins, baths, etc., flows through the check valve *C*. The valves *B* and *D* are used only when repairs are required. The pump is started at 5 a.m., and as the 60 lb. pressure is not required until 8 a.m., the tank is refilled by that time. The overflow is a 5-in. pipe made to unscrew at the bottom when the tank requires cleaning.



ARRANGEMENT OF VALVES AT SUPPLY TANK

Kingston, Ont., Canada. JAMES E. NOBLE.

Economizing Wiping Cloths

Once one starts to look around where economies can be practiced, it is surprising in how many places savings can be made. Possibly nowhere is this more true than in the power house. Moreover, in attempting to initiate new methods of economy, perhaps there is no better way to start than to visit other power houses, large and small, to find out what they are doing.

In visiting a number of power houses recently, the writer noticed a practice in vogue in one which seems well worth passing on. It is a money saver that can be carried out easily, with little trouble and without additional expense for labor. This stunt is to renovate the wipers used for cleaning the machines and apparatus, instead of throwing them away. In engine rooms the work performed by wipers and rags is severe, and it does not take

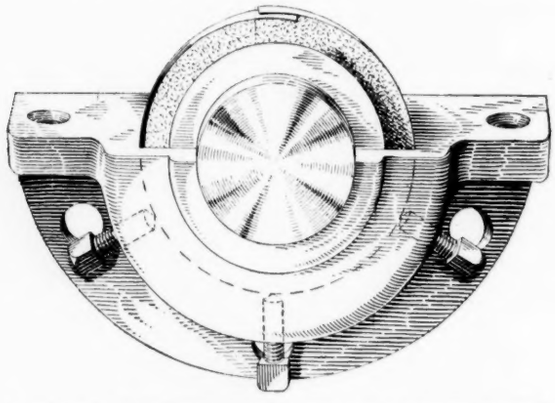
long for a cloth to get so dirty that it is of no further use. From the engine room it goes to the boiler room, where it is used for a short time longer, then is thrown out or used to light fires.

The cost of cotton goods has gone up, and at present prices any means of extending the life of these clothes several hundred per cent. is worth trying, especially when it can be done at a small cost. The way this was being done in the station mentioned was to collect all cloths and keep them until a hundred or more were dirty. When a sufficient number had accumulated, they were treated with steam to remove the oil. They were then thrown into a centrifugal washing machine, installed in close proximity to the boiler room, and subjected to boiling for forty minutes or more in a solution of soap powder. At the end of this time the water was drained off and clean boiling water run in for twenty minutes more, the washing machine being revolved all the time, after which the cloths were taken out and allowed to dry. The ordinary rags subjected to average usage can thus be treated three times, and at a cost equal to about one-fifth of new wipers. R. K. Long.

Chicago, Ill.

Fibrous Packing in a Turbine

I was up against an emergency when the carbon packing of a small high-speed turbine direct-connected to a boiler-feed pump became worn so that the steam blew the oil out of the bearing at the end of the shaft. On taking the casing apart, the packing was found in such condition that it could not be re-used, and being a special carbon ring packing, we had none in stock. To get the pump going, I put in Palmetto packing, but as there was no gland to tighten up in the usual way, I fixed it in the manner shown in the illustration. The set has been running first-rate for over a week. This may help someone else in an emergency. Howard Mason.



FIBROUS PACKING IN PLACE OF CARBON RINGS

Amsterdam, N. Y.

Wanted: Pointers on the Treatment of Boiler Water

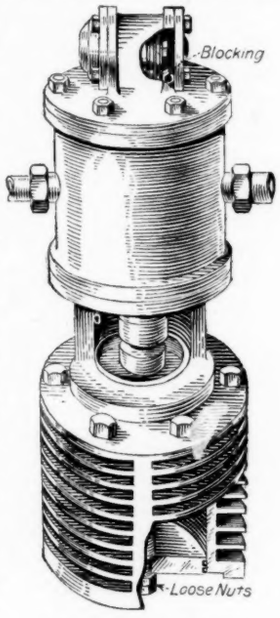
I would like to have the benefit of the experience of some of the readers of *Power* who are using tri-sodium phosphate for treating boiler water—how they use it and also their methods of making tests of the treated water.

I believe this will be of interest to many engineers. We have 12 boilers and do not seem to be getting the results we should. J. P. Colton.

Lima, Ohio.

Holding Piston To Tighten Nut

A local ice and storage plant has a number of Westinghouse 9½-in. air compressors, and some of the air pistons became loose on the rod. The illustration shows how the floating piston operating the valve was blocked so as to keep the steam pressure on the upper side of the piston holding it firmly against the lower cylinder head so the nut could be tightened. This was done by removing the valve cover and inserting a small nut between the valve piston and the cap and replacing the cover. When the steam was turned on, the slide valve being blocked holding the right valve port open, the pressure exerted on the top of the large piston held it tight against the lower head, and the nut on the air piston was drawn up securely without danger of injuring any part of the compressor as sometimes happens in doing this job.



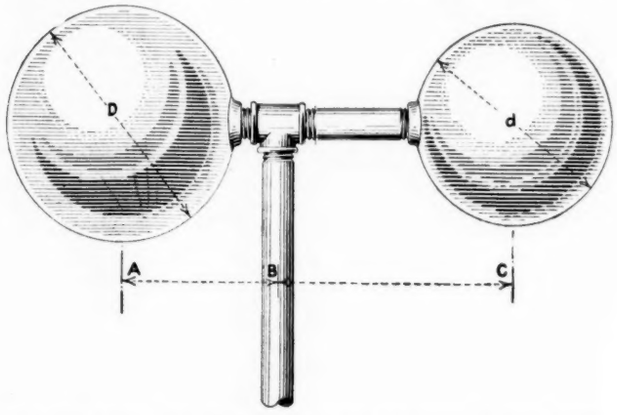
AIR PISTON LOOSE ON ROD

W. F. Bentley, Jr.

Missouri Valley, Iowa.

Two Floats Instead of One

The letter by Mr. Saller in the issue of Jan. 2, page 26, reminds me of a similar job where the floats available were of different diameters. To overcome the difference in buoyancy, the distances *AB* and *BC* were made such that $D^3 \times AB = d^3 \times BC$, D and d being the diameters of the floats respectively. The two floats operated a valve satisfactorily where one had failed. M. D. Place.



FLOATS LOCATED WITH REGARD TO THEIR BUOYANCY

Norfolk, Mass.

Inquiries of General Interest

Circular Inch and Circular Mil—What is a circular inch, and what is a circular mil? T. R.

A circular inch is the area of a circle 1 in. in diameter, or 0.7854 sq.in. A circular mil is the area of a circle 0.001 in. in diameter, or 0.0000007854 sq.in.; hence, 1 circ.-in. = 1,000,000 circ. mils.

Stiffening Dished Head Around Manhole Opening—What provision should be made for stiffening a dished head of a steam drum that has a manhole? R. C. M.

A manhole opening in a dished head should be stiffened by flanging to a depth of not less than three times the thickness of the head measured from the outside.

Negative Slip of a Pump—What is negative slip of a pump, and how is it caused? W. L. A.

A pump has negative slip if the discharge is greater than the plunger displacement. This sometimes occurs with pumps that handle large quantities of water, from the tendency of the suction water to continue flowing after the pump plunger has been brought to rest.

Designation of Dished Heads—Are dished heads designated as convex and concave according to the form of the outside or the form of the side presented to pressure? B. H.

Dished heads for steam drums and other pressure vessels are designated according to the form of the outside of the head. Convex heads are understood to have pressure on the concave side and concave heads to have pressure on the convex side.

Testing Condition of Pump—How can a test be made to determine whether the packings of the water piston and the suction valves of a direct-acting steam pump are in good order? A. R. D.

With the water cylinder flooded, close the discharge valve and admit sufficient steam pressure to produce the normal water pressure. If the piston speed of the pump is then about 1 per cent. of normal, the water-piston packing and suction valves may be considered tight enough for good operation.

Cement for Repairing Commutators—What are the materials used to make a cement for repairing commutators where the mica has been burned out between the bars? R. C. B.

There are several mixtures that may be used for this purpose. Litharge mixed with glycerin to form a paste has been utilized quite extensively. Another combination is plaster of paris and shellac. In either case the crevice is thoroughly cleaned of all burnt mica and then filled with the paste, which will harden in a short time.

Synchronism of Generators and Motors—What is meant by synchronism with reference to electric generators and motors? L. B.

Synchronism with respect to alternating-current generators is the condition which exists when the electromotive forces or currents generated by two or more machines pass through their zero and their maximum values at the same instant. Synchronism with reference to alternating-current motors refers to the speed of the stator revolving magnetic field. If an alternating-current motor has the same number of poles as the generator, the magnetism of the motor's stator will revolve at the same speed as the generator. In a synchronous motor this would be the speed of the rotor.

Cutting Out an Armature Coil—Which is the better method of repairing an open coil in a series-wound armature, to short-circuit the commutator bars at one of the burnt spots on the commutator or to connect with a jumper the two bars to which the leads of the open coil connect? State the advantage of either method. C. O. A.

For a quick repair short-circuit the commutator bars at one of the burnt spots. This can be done by sawing out a little of the mica from between the bars and expanding the corners so that they meet across the insulation. One of the defects of this method is that a coil is cut out for every pair of poles; that is, in a 4-pole machine two coils are cut out of the winding and in a 6-pole three coils. However, many machines have been satisfactorily repaired in this way. Connecting the commutator bars with a jumper to which the open coil is joined is the best method, as then the open coil only is cut out of circuit. This requires considerable time, and it may not always be possible to make the repair without removing the armature from the machine.

Computation of Brake Power Developed by Waterwheel—What number of brake horsepower is developed by a horizontal turbine waterwheel when the horizontal length of brake arm is 72 in., tare weight of brake 30 lb., total pressure exerted by brake on scales 147 lb. and speed of brake wheel 220 r.p.m.? H. R. C.

The brake horsepower is given by the expression:

$$\frac{\text{Length of brake arm in feet} \times 2\pi \times \text{net pressure, lb.} \times \text{r.p.m.}}{33{,}000}$$

Hence under the conditions quoted, the power developed would be

$$\frac{\frac{72}{12} \times (2 \times 3.1416) \times (147 - 30) \times 220}{33{,}000} = 29.41 \text{ b.hp.}$$

Strength of Rivets Based on Size After Driving—Is the strength of rivets of a boiler joint to be based on the commercial size of rivets used or the size of the rivet holes? R. M.

For dependence on shearing resistance of the rivets they must completely fill the holes and their strength must be based on their size after being driven. In proper construction the rivet holes are drilled or reamed to full diameter with the plates, butt straps or heads bolted together, and the holes are to be held fair during the process of riveting. To insure complete filling of the holes it is required that "rivets shall be machine-driven wherever possible, with sufficient pressure to fill the rivet holes and shall be allowed to cool and shrink under pressure." Hence, when it is assumed that the work is properly done, computation of the strength of rivets is to be based upon diameter of rivets equal to the diameter of the holes.

Laying up a Boiler—What attention should be given to a boiler that is to be laid up for three to six months? G. W. A.

Wash out the boiler and clear the steam-gage connections and water column and gage-cocks and their connections of mud, scale or rust. Put one to two gallons of mineral lubricating oil in the boiler, and after introducing feed water so the boiler will be filled to the point of overflowing at the safety valve, slowly drain off the water so as to leave all portions of the interior coated with oil. After driving off all moisture with a very light fire, close the boiler up and take means for keeping it perfectly dry inside and outside. To prevent rusting of the flues and uptake connections from deposits of moisture out of the atmosphere, the ashpit doors, fire-door, cleaning doors and uptake connection should be sealed, and to better guard against rusting from this cause the uptake should be disconnected from the stack as well as sealed.

Use of Flush Front Settings—Why are some return-tubular boilers set with flush fronts and some set overhanging? A. J. K.

When a boiler is provided with flush ends, a flush front must be used to form the front of the smoke connection. When the boiler is provided with a dry sheet, or extension of the shell beyond the tube sheet for forming a smoke connection, sometimes, for better appearance or better headroom for the fireman, the open end of the dry sheet is placed behind a flush front. In that case the front wall of the setting containing the fire-door arch must be built up under and around the dry sheet. This is objectionable, for, as in a flush-end boiler setting, settling of the front wall or failure of the fire-door arch makes an opening for escape of hot furnace gases direct to the chimney without traversing the heating surfaces of the boiler. When an extension is thus used with a flush front, there is danger that the dry sheet and front flue-sheet rivets may become burnt.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Public-Utility Service

In a paper read before the recent annual meeting of the Indiana Engineering Society, Peter Junkersfeld, of the Commonwealth Edison Co. of Chicago, showed how public-utility service was affected by local conditions, particularly by the density of business, and why in selling electric service it was equitable to charge the large consumer a lower rate than the small resident customer.

As a definite example of the effect of density of service in Chicago, he presented the accompanying table in which column A shows approximately the relative investment required to supply electrical energy untransformed at a large substation; column B that to render complete electric service to one of five residence customers in a block, and column C that to render the same service to one of 50 residence customers in a block.

EFFECT OF DENSITY OF SERVICE

	A Per Cent.	B Per Cent.	C Per Cent.
Generating station	12.3	12.3	12.3
Transmission system	3.2	3.2	3.2
Substations	....	4.4	4.4
Distribution to block in which home is located	....	9.3	9.3
Distribution within such block	....	58.6	12.0
Meters	....	9.0	9.0
Lamps	....	3.2	3.2
	15.5	100.0	53.4

For simplicity of illustration it was assumed that the electric utility has only two classes of customers, that the yearly load factor of each customer in the two classes is the same, and that the same yearly fixed charge could be applied to the entire investment used for each customer. Then, as shown in the table, the investment charges for the consumer of untransformed energy would be only 15.5 per cent. of that for the residence customer who is one of five in a block.

If there are fifty similar small customers in a block, as in the case of large flat buildings, the total investment charges, as shown in column C, are reduced almost one-half.

The reason for this large reduction is that for mechanical reasons the poles, the primary wires and the secondary wires necessary for five customers to the block are also sufficient to supply 50 customers to the block. The only addition in investment for 50 instead of 5 customers in a block is the larger transformer and the additional number of service drops. If every block in a city or in an area served for 50 or more customers, there would be a considerable reduction also in the items of transmission or substations, and of distribution to the boundary of the block. The foregoing, together with the table, illustrates the very great influence of density of investment required to render electric service to homes. It also shows that the investment per unit of demand is 6 or 7 times as great for the small customer in column B as for the large customer in column A. The interest and other fixed charges in this investment must be paid from month to month and from year to year whether the customer uses the service only five minutes per day or five hours per day. This is one of the reasons why a minimum bill each month is equitable and fair. Again, the cost to supply electric service depends on local conditions and habits. If every householder in a block takes electric service instead of only a few in the block, the cost will be less and hence finally the rate will be less and all will share the benefit.

All the expenses per kilowatt-hour (other than fixed charges on the investment) incurred in supplying electrical energy untransformed are only about 6 or 7 per cent. of those incurred in rendering electric service to a small customer (5 customers to the block). The reason is that in the case of untransformed energy in bulk, the only large expenses are those in operating and maintaining the generating station and the transmission lines. All the other expenses, such as the cost of reading and maintaining meters and rendering and collecting of bills for such large customers, are relatively small items.

In the case of the very small customer, the operating and maintenance expenses in connection with the substation and complete distribution system, meters and lamps and often free repairs for customers, are a large item. The general expense incurred in reading, testing and maintaining meters, rendering and collecting bills and keeping and carrying the account is just as great for the smallest customer as for a moderate-sized customer. This is another reason why a proper minimum bill is necessary to prevent injustice, and it therefore is equitable.

The cost each month of reading the meter, entering on the books, rendering the bill and making the collection is about 16c. per bill. This is repeated twelve times a year. This 16c. is a large proportion of a bill for electric service that is often $1 or less per month. If such bills could be rendered quarterly and collected without prohibitive loss, the saving would be considerable, and of which saving the customer would ultimately receive the benefit.

The two cases just considered are extremes—one a very large user and the other a very small customer. For the latter the investment cost per kilowatt of demand was nearly seven times and all other costs per kilowatt-hour about fifteen times as great. A large proportion of the business of an electric utility, however, lies between these two extremes. It is difficult to determine accurately the relative cost to supply each of the many different customers under widely varying conditions of service between the two limits considered. It is, however, necessary to keep the matter of cost constantly in mind because any customers that are served below cost to render service involve a loss that must eventually be borne by the other customers. It is one of the present problems and duties of every electric utility and of the commission having jurisdiction to see that the number of customers served below cost shall not become too large and thus prevent an injustice to all other customers.

Even if it were possible, it is not at all necessary that all customers should afford the same percentage of profit. In a great many instances it is necessary, in order to secure additional customers, that they be served at a lower margin of profit than is afforded by some existing customers. Every customer added to the utility, if he affords any profit at all, is a source of benefit to all other customers, provided always that there is no discrimination in rates under like conditions of service. Take, for example, the electric-railway business in Chicago. During the first two or three years this business was served at practically no profit. The demonstration was, however, successful, and as a result the sale of electrical energy to the railways increased rapidly and soon afforded a reasonable profit. Since then this railway business has made possible large and economical power houses and transmission systems from which all the other customers have received large benefits, as demonstrated by the many reductions in rates.

In this respect the sale of electrical energy is not essentially different from the sale of the output of a manufacturer who makes a moderate profit on his regular line. To run his factory more economically it is advisable for him to take on an additional line and, if possible, something that can be manufactured during the particular season of the year when the demand for his regular product is at a minimum. When first taking on the additional line, he is entirely justified in doing so at a low margin of profit or no profit at all, and by so doing increase the quantity of his entire production so much that he is finally able to cut down the margin of profit both on the standard line and on the additional line, thus benefiting both his old and his new customers.

The fixed charges on investment, interest, depreciation and the like are the largest portion of the cost to serve the majority of users of electric service. The matter of load factor is therefore of vital importance; that is, if a dollar invested in the electric utility can be made to work twice as many hours per day, the fixed charges are correspondingly reduced. This is what happens if the same equipment can be used to supply the peak of one or a set of customers during the early hours of the day and another set of customers during the evening and night hours with no overlapping of the two peak demands. Most manufacturers have their peak load at about 10 o'clock in the morning. The business and residence lighting peak comes in the late afternoon or evening. This so-called diversity of demand is one of the fundamental and important economic reasons for massing of electricity production on a large scale.

Discovery of a Vast New Oil Field

Official recognition of the tremendous value and potential possibilities of the shale of the Green River formation in northwestern Colorado and northeastern Utah has been afforded by the United States Government in the form of a report prepared by Dean E. Winchester, of the Geological Survey.

In this report, which has just been made public, Mr. Winchester estimates that in Colorado alone there is enough shale to produce twenty billion barrels of oil, while 300,000,000 tons of ammonium sulphate, worth from $50 to $60 per ton as fertilizer, could be recovered as a byproduct in the manufacture of the oil. When it is considered that the total yield of crude petroleum from all the oil fields of the United States during 1916 was less than 300,000,000 barrels, some idea may be obtained of the tremendous value of this practically untouched resource.

For several years it has been known that some of the shale of the Green River formation in Colorado and Utah would produce oil when subjected to destructive distillation,

but the yield of petroleum from the oil fields was so great that production by distillation did not seem to be feasible.

The oil shale of the United States has received very little attention, chiefly because petroleum has been so abundant, but before petroleum was discovered in Pennsylvania the Mormons distilled oil from shale near Juab, Utah, where the remains of an old still can yet be seen. Many attempts have been made to distill cannel coal, and a few experiments have been made with the Devonian black shale of the East, but no permanent shale-oil industry has been established in America. In Scotland, however, several well-established plants mine and distill shale of the Carboniferous Age. These operations have paid dividends in spite of the very low yield of oil, because of the cheapness of labor, the value of the byproducts and lack of competition with petroleum. All mining in Scotland is underground, which greatly increases the expense, but at many places in Colorado and Utah the rich shale has only a light overburden and could be mined with a steam shovel and is at least 3 ft. thick.

The report states that there are at least 10 different valuable products which may be obtained from this shale, as follows: Permanent gas, used principally for fuel in the retorts; naphtha, gasoline and motor spirit; burning or lamp oil; intermediate oil used for gas making; lubricating oil; solid paraffin; still grease; still coke, which contains some oil and is used for gas fires, smokeless fuel and carbon for electrical purposes; ammonia sulphate and liquid fuel, used in the refineries.

From the results of the tests made in the field and in the laboratory it is apparent that this constitutes a vast and highly valuable natural resource which will aid materially in solving the problem of where our future supply of oil and its attendant byproducts is coming from.

NEW PUBLICATIONS

MANUAL FOR ENGINEERS. By Charles E. Ferris, B. S. University Press, Knoxville, Tenn. Leather; 220 pages; 3x5¾ in. Price, 50 cents.

This small manual for engineers, now in its 20th edition, consists principally of tables that, as stated by the author, have been freely drawn from manufacturers' handbooks, books for engineers, periodicals and other sources. They consist of tables such as of areas and circumferences of circles, squares, cubes, square and cube roots, table of saturated steam, weights of different materials, electrical tables and the general run of tables usually found in small pocket handbooks. The volume can be carried in the vest pocket, has 54 pages of advertising and is indexed.

FRANCO-AMERICAN TRADE. Report to the Manufacturers' Export Association by the American Industrial Commission to France. Published by the Commission and procurable from the American Manufacturers' Export Association, 160 Broadway, New York. Boards; 8x11 in.; 256 pages; illustrated. Price, $5.

What are to be the trade opportunities with France at the close of the war? What is she going to need from us? Are we to deal with a broken, depleted nation, or will the millions of dollars' worth of equipment which has been imported under stress be applied, by an organization which the exigencies of war have sharpened to a keen efficiency, to the arts of peace? What terms will her necessities impose? How much disposition will there be for the Allies to club their resources, buy as little and sell as much outside as possible? The belligerents cannot recoup their losses by selling to themselves or to one another. What sort of a struggle is there to be for our own and other markets? Everybody got ready to supply the abandoned markets of South America when the war began, but the current turned the other way. Are we going to see the post-bellum opportunities any more clearly and be any better prepared to meet them?

The commission whose report is under review visited France under the most auspicious circumstances in September and October of last year, with the object of preparing the two friendly nations for a closer commercial relationship under new conditions, and its report, while inconclusive, throws a lot of light upon the subject. Its twenty-five chapters treat of: The Inception of the Commission; The Tour; Trade and Tariff; Industry and Plant Construction; Industrial Machinery; Agriculture and Agricultural Machinery; Labor; Syndicates and Coöperative Societies; Chambers of Commerce and Courts of Commerce; Seaports and Shipping; Transportation; Hydro-electric Power; Mining and Metallurgy; Coal; Chemical Industry; Alcohol; Social Welfare; City Planning; Hotel and Resort Industry; Education; General and Technical; Devastated Regions; The Central Association for the Resumption of Industrial Activity in the Invaded Regions; Belgian Reconstruction; The Lyons Sample Fair; and Bibliography. Reports of the American Chamber of Commerce in Paris are appended. Numerous maps are included, and many halftone reproductions of photographs excellently printed on a high grade of paper make the volume quite different from the ordinary commercial report. The amount of work put into this investigation and report by experts of high standing in their various lines would amount to an impossible figure if paid for at the usual rate, and the price charge is no more than sufficient to reimburse the commission for the mechanical cost of the volume.

ENGINEERING AFFAIRS

The Southwestern Electrical and Gas Association will hold its thirteenth annual convention in Dallas, Tex., Apr. 26-28.

The New England Water-Works Association will hold a meeting at the Hotel Brunswick, Copley Square, Boston, Mass., Feb. 14.

The Providence Section of the A. S. M. E. will hold a meeting on Feb. 13. Luther D. Burlingame will speak on "The Units of Measurements in Relation to the Metric System."

The Cincinnati Section of the A. S. M. E. will hold a joint meeting with the Engineers' Club of Cincinnati on Feb. 15. The subject of Combined Stresses will be discussed by A. Lewis Jenkins.

The American Institute of Steam Boiler Inspectors of New York City at the January meeting elected the following officers for the ensuing year: President, T. T. Parker; vice-president, J. G. Shaw; secretary, J. H. Pollard. As previously announced the Institute will hold its annual banquet on Feb. 24 at the Marlborough Hotel, at 8 p.m.

TRADE CATALOGS

Uniflow Boilers. Uniflow Boiler Co., Inc., Harrison Building, Philadelphia, Penn. Circular. Illustrated.

Centrifugal Pumps. Lawrence Pump and Engine Co., Lawrence, Mass. Catalog C; pp. 48; 6x9 in.; illustrated.

Stanley Cotton Belting. Stanley Belting Corporation, 32-40 South Clinton St., Chicago, Ill. Catalog; pp. 4; 3½x6½ in.

Skip Hoist for Ashes. R. H. Beaumont Co., Drexel Building, Philadelphia, Penn. Catalog No. 32; pp. 16; 6x9 in.; illustrated.

A Chain of Evidence. Morse Chain Co., Ithaca, N. Y. Publication No. 15, covering small power drives; pp. 20; 6x9 in.; illustrated.

Steam Traps, Reducing Valves, Regulators, Governors, Etc. Kitts Manufacturing Co., Oswego, N. Y. Catalog No. 12; pp. 4; 9x12 in.; illustrated.

Western Electric Electrical Supply Year-Book. Western Electric Co., 195 Broadway, New York. Pp. 1312; 7x10 in.; illustrated. This is the third edition of this book and contains uniform list prices with one basic discount.

"Increasing Today's Profits." Diamond Power Specialty Co., Detroit, Mich. Bulletin No. 117; pp. 24; 8x10½ in.; illustrated. This is a study of waste and pointers on the use of fuel and shows the application of Diamond soot blowers.

Vasco-Marvel Semi-High-Speed Steel. Vanadium-Alloys Steel Co., Pittsburgh, Penn. Folder. In addition to information regarding properties of this steel, high-speed steel classification of extras adopted July 22, 1915, are given.

Direct-Current Motors and Generators. Roth Brothers & Co., Chicago, Ill. Bulletin No. 182. Pp., 16; 8½x11 in.; illustrated. This bulletin contains a full description of the company's line of direct-current motors and generators.

Injectors, Ejectors, Grease Cups, Etc. Penberthy Injector Co., Detroit, Mich. Catalog No. 28; pp. 80; 6x9 in.; illustrated. This contains valuable data on injectors and shows a complete line of brass specialties pertaining to steam, plumbing and automobile accessory trades.

Byers Wrought Iron Pipe. A. M. Byers Co., Pittsburgh, Penn. Bulletin No. 27; pp. 40; 8½x11 in.; illustrated. This bulletin, entitled "The Experience of Practical Men," contains testimonials from users of this pipe and also an explanation of the resistance to corrosion, etc.

Cochrane Heaters for Steam Power Plants. Harrison Safety Boiler Works, Philadelphia, Penn. Catalog No. 710; pp. 106; 6x9 in.; illustrated. This is a treatise on the utilization of exhaust steam and the heating, softening and metering of boiler-feed water as accomplished by Cochrane apparatus.

Apparatus for the Location of Thermal Transformation Points—The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Penn. Bulletin 866-A; pp. 16; 8x10½ in.; illustration. The bulletin describes this company's apparatus for determining the temperature at which certain physical and chemical changes take place when metals are given a heat treatment. An interesting series of six charts is shown, exhibiting the transformation points in samples of carbon steel containing 0.01, 0.1, 0.2, 0.3, 0.4 and 0.6 per cent. of carbon respectively.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points are as follows:

ANTHRACITE

	Circular		Individual	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
Buckwheat	$3.60	$3.10	$6.00@6.50	$3.00@3.50
Rice	3.10	2.50	5.50@5.75	2.60@3.00
Boiler	2.95	....	5.00@5.25	.....
Barley	2.85	2.25	4.20@4.60	2.45@2.60

BITUMINOUS

Prices per gross ton for Boston delivery:

	F.o b. Mines		Alongside Boston	
	All-Rail Rate $2.60 to Boston		Water Coal	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
Clearfields	$4.60@5.15	$2.35@2.60	$8.25@8.50	$5.50@5.75
Cambrias and Somersets	4.85@5 50	2.75@3.00	8.60@8.75	.....

	F.o.b. Hampton Roads		On Cars, Boston	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
Pocahontas and New River	$6.50@6.75	$2.85	$9.00@9.25	$6.00@6.50

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports are as follows:

ANTHRACITE

	Circular		Individual	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
Buckwheat	$2 75	$2.75	$6.25@6.75	$3.50@3.75
Rice	2.20	2.25	4.50@5.00	3.25@3.50
Barley	1.95	1.75	3.00@3.25	2.75@3.00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy		Port Reading	Mine Price	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	Feb. 10, 1917	One Year Ago
Clearfield	$5.75@6.25	$3 90@4.00	$5.75@6.25	$4.25@4.75	$2.35@3.45
South Forks	6.00@6 50	4.00@4.25	6.00@6.50	4.50@5.00	2 45@2.70
Nanty Glo	6.00@6.50	4 20@4.25	6.00@6.50	4.50@5.00	2.65@2.70
Somerset	5.75@6.25	3.75@4.00	5.25@6.25	4.25@4.75	2.20@2.70
Quehamoning	6.00@6.50	3.75@4.00	6.00@6.50	4.50@5.00	2.45@2.70

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.10	.90	3.00	1.80
Boiler	1.95	....	3.15	....
Barley	1.85	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Feb 10, 1917	One Year Ago
Slack	$4.75	$1.35@1.60
Mine-run	5.00	1.50@1.75
¾-in.	5.00	1.60@1.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines:

	Springfield	Clinton and Sullivan Cos.
Steam lump	$3.25@3.50	$2 75@3.25
Egg	3.25@3.50	3.00@3.50
Nut	3.00@3.50	3.00@3.25
Mine-run	3.00@3.25	2 75@3.25
Screenings	2.75@3.00	2.25@2.75

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless
Lump	$3.75@4.00	$3.75@4.00	$5.00@5 25
Egg	3.75@4.00	3.75@4.00	4.75@5.00
Nut	3.75@4.00	3.50@3.75	.....
No. 1 nut	3.75@4.00	.....	.....
No. 2 nut	3.50@3.75	.....	.....
No. 3 nut	3.25@3.50	.....	.....
No. 1 washed	3.50@3.75	.....	.....
No. 2 washed	3.25@3.50	.....	.....
Mine-run	3.00@3.25	3.25@3.50	4.50@5.00
Screenings	3 00@3.25	3.25@3.50	.....

Hocking lump, $4; splint lump, $4.

St. Louis—Price per net ton f.o.b. mine:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago	Feb. 10, 1917	One Year Ago
6-in. lump	$2.75@3.00	$1.60@1 75	$2.75@3	$1.35@1.50	$2.50@2.75	$1.15@1.25
2-in. lump	.....	1.40@1.50	.....	1.25@1 35	2.25@2 50	.95@1.15
Steam egg	.....	1.40@1.65	.....	.....	2.25@2.50	.....
Mine-run	2.75@3.00	1.15@1.20	2.25@2.50	1.10@1.15	2 00@2.25	.90@1.15
No. 1 nut	.....	1.25@1.40	.....	.....	.....	1.00@1.25
2-in. screen.	2.50	.85@1 00	2.35@2.50	.75@ .85	2.25	.75@ .85
No. 2 washed	3.00@3.25	1.50@1.60	2.75	1.40@1.50	.....	1.40@1 50

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines:

	Mine-Run	Washed Mine-Run	Washed Nut
Pratt	$3 00	$4.50	$4.50
Big Seam	2.50	$3.75@4.25	$3.75@4.25
Black Creek	$3.00@3.25	4.50	4.50
Carbon Hill	2.50	4.00	4.00
Cahaba	3 50	4.50	4.50

PROPOSED CONSTRUCTION

Calif., Santa Barbara—The Santa Barbara Gas and Electric Co. will construct an addition to its station on Quarantine St.

Conn., New Milford—John H. Lancaster, Litchfield, is interested in a company which proposes to construct a power plant on the Housatonic River to manufacture and distribute electricity over a large area.

Del., Milford—The Board of Light and Water Commissioners will improve and extend its electric-light plant. J. F. Anderson is secretary.

Ill., Bondville—The Bondville Electric Light Co. will improve its plant. J. C. Flowers, superintendent.

Ill., Carrollton—City Council plans to hold election to vote on $25,000 bond issue to install electric-light plant.

Ill., Joliet—The Electric Development Co. of Sanitary District of Chicago contemplates a hydro-electric plant on Brandon Rd. to develop 28,000 hp.

Ind., Corydon—The Middle West Utilities Co., controlling United Gas and Electric Co., New Albany, plans hydro-electric power plant on Blue River near Corydon.

Ind., Terre Haute—Plans are being prepared by D. B. Shourds, Arch., 511 Tribune Building, for a one-story addition to the boiler shop of the Terre Haute Boiler Works. W. H. Cliff, 13th St. and Vandalia Rd., president and manager.

Iowa, Manilla—City voted $5000 bonds to improve electric-light plant.

Kan., Bronson—W. B. Rollins & Co., Railway Exchange Building, Kansas City, Mo., is preparing plans for an electric-light plant.

Ky., Jenkins—The Consolidated Coal Co. contemplates transmission lines from Jenkins to supply electricity to Whitesburg, Kona and other central points. Address W. Burdine, Whitesburg.

Mass., Mansfield—The Union Light and Power Co., Franklin, plans to construct a 13,000-volt transmission line from Mansfield to North Attleboro.

Mich., Battle Creek—The Consumers Power Co. plans to construct a turbine room and boiler house at its electric power plant. Estimated cost, $250,000.

Mich., Marquette—The Piqua Handle Co. has had plans prepared for a power plant. B. Hogan is contracting engineer.

Mich., Sheboygan—The Sheboygan Electric Light and Power Co. will improve and extend its power house, dam and substation on the Black River. G. S. Williams, Ann Arbor, is hydraulic engineer.

Minn., Wabasha—Bids will be received about Mar. 1 by the Wabasha Gas Co., 309 Northwestern Bank Building, Minneapolis, for a gas plant. Estimated cost, $35,000. E. E. Collins, president.

Mo., De Kalb—The De Kalb Light and Power Co., recently incorporated, will install service transmission line from Hammond packing plant to Croy Hill.

Neb., Hastings—City will soon receive bids for improving electric-light plant. Estimated cost, $10,000. A. T. Bratton is city clerk.

N. Y., Bedford Hills—Bids will be received by the Board of Managers of the New York State Reformatory for Women until Feb. 16 for rewiring the buildings. J. Wood, president. L. F. Pilcher, Capitol, Albany, state architect.

N. Y., New York—(Borough of Manhattan)—The Interborough Rapid Transit Co. is having plans prepared for a substation at 150 West 16th St. Estimated cost, $40,000. G. H. Pegram, engineer.

Ohio, Newark—The Ohio Light and Power Co. will extend its transmission lines to Pleasantville, Baltimore and Basil.

Okla., Kaw City—City is having plans prepared for an electric-light plant. Estimated cost, $10,000. Benham Engineering Co., Colcord Building, Oklahoma, engineer.

Okla., Oklahoma—M. L. Cunningham, State Highway Engineer, has estimated the cost of a power plant for the State Capitol Building at $187,000.

Okla., Pawnee—The city has retained the Benham Engineering Co., Colcord Building, Oklahoma, as consulting engineer for the proposed gas plant. Estimated cost, $150,000.

Ont., Brantford—The City Council plans to install a hydro-electric system.

Ont., Toronto—The British Forgings, Ltd., is having plans prepared for an electric-light plant on Cherry St. Estimated cost, $25,000.

Penn., Easton—The Easton Hospital Association, 249 Spring Garden St., is having plans prepared by W. M. Michler, architect, Drake Building, for a power house. J. Carter, 231 Clinton Terrace, secretary and treasurer.

Penn., Philadelphia—The Colonial Knitting Mills, Inc., plans to construct a power plant at its new mill at 25th St. and Hunting Park Ave. J. P. Quinlan, vice-president.

Penn., Philadelphia—The Philadelphia & Reading Ry. plans to construct a one-story power plant at its Erie Ave. yards. S. T. Wagner, Reading Terminal, chief engineer.

Tenn., Cumberland Springs—L. Motlin, Suberland Springs Hotel, is reported interested in a plan to instal an electric-light plant in Cumberland Springs.

Tenn., Nashville—The City Council plans to hold election to vote on $50,000 bond issue to improve electric-light plant. J. W. Dashiell, city clerk.

Tex., Gatesville—The Gatesville Power and Light Co. will rebuild its plant recently destroyed by fire with a loss of $75,000. J. R. Raby is president.

Tex., Hubbard—The Union Central Light and Power Co. is in the market for equipment and material for extending its transmission lines. N. A. Bass, president.